Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. X. NEW YORK, MARCH, 1905. No. 1.

"Compressed Air,"

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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Those who fail to receive papers promptly will please notify us at once.

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VOL. X. MARCH, 1905. NO. 1

A New Volume.

In beginning the tenth year of the publication of COMPRESSED AIR we feel justified in saying a word to the readers and advertisers of our magazine, whose support has demonstrated the correctness of the idea which nine years ago resulted in the establishment of this publication.

COMPRESSED AIR offers no excuses for its existence. It has proven its value to readers and advertisers alike. Its history has again demonstrated the field open to the specialist. As with the men themselves, so it is with the publications through which they gain their knowledge of current happenings.

Since the establishment of this magazine the field of compressed air has broadened to a greater degree than its sanguine advocates had hoped. Many minds, centred on the development of mechanical means for accomplishing tasks hitherto confined to the hands alone, have produced some remarkable achievements in the line of labor-saving tools and devices. In these compressed air has figured to an increasing degree. No better evidence of this can be found than in the large number of concerns engaged in the production of tools or machines utilizing compressed air. The pneumatic engineer, while not as numerous as the electrical engineer, is fully as important.

In this field COMPRESSED AIR offers a monthly summary of important events and notable discoveries and improvements. To those who would be in touch with the subject it offers an unequaled opportunity to do so. To others it is not of interest. We have our particular place and our aim has been and will continue to be to fill it well. That, in a few words, tells what may be expected of COMPRESSED AIR in the year to come.

Air Brakes.

According to the provisions of the so-called "air brake" law, it is necessary for the railroads to install this system of power brakes on their freight as well as their passenger trains. Instruction for the employees, who were called upon to operate them, became necessary and "instruction cars" were put in service on many of the roads. On several occasions COMPRESSED AIR has described and illustrated instruction cars which were in actual use on railroads in this country.

It is interesting to read what the Interstate Commerce Commission has to say on this subject in its last report. The Commission charges that the air brakes are not as efficient as they should be and divides the blame between the railroads, which it says do not properly educate the men, and the men them-

selves who are not always inclined to give the brake equipment proper attention. In some cases this must be charged to the natural antipathy of the employe, long in service, to any radically new device. He has not the confidence in it and prefers the old way without giving the new method a fair test.

The report says:

"The report of our inspectors show that the provisions of the air-brake law are generally well observed so far as the proportion of air-brake cars in service is concerned. In many instances, however, these cars do not receive the attention they should, and are permitted to run in such ineffective condition as to be really inoperative so far as the brakes are concerned. Leaky train pipes and improper piston travel in brake cylinders are the most frequent complaints, and in nearly every instance where these complaints are common it is found to be due to insufficient repair force at points where cars are inspected and repaired. In many cases engineers complain that they cannot pump sufficient air to enable them to control their trains entirely by air brakes, and they have no confidence in their ability to control their trains. They thus insist that trains shall be controlled by hand brakes in all dangerous places, holding the air reserve for use in emergencies only. It is found that generally where such conditions exist they are due to causes which may be easily remedied, such as leaky train lines, dirty and inoperative triple valves, and improper piston travel, all due to imperfect inspection and care of brakes, or air pumps not of sufficient capacity to furnish air for the number of brakes used. Another reason is failure of the roads to properly educate their employees in the use of air brakes.

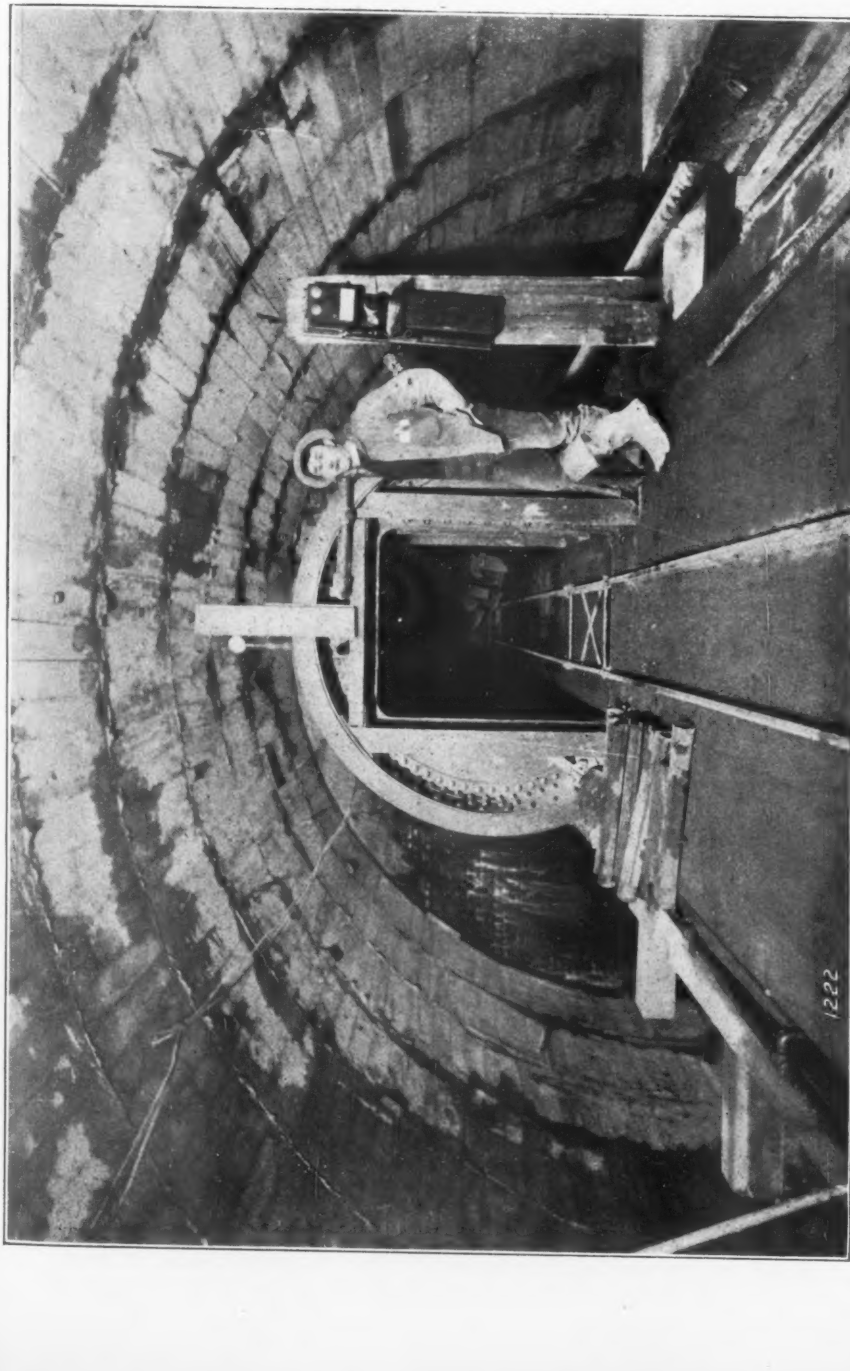
"It has been found that in many cases where trains were run without the required 50 per cent. of air brakes in operation it was due entirely to the neglect of trainmen, who had positive orders to use 50 per cent. of air, but who did not take the trouble to couple the air together, thus placing their employers in the attitude of violators of the law."

This report bears out the fact often observed heretofore that compressed air machinery is often classed as inefficient because those in charge fail to give it proper attention. Electrical machinery, as a rule, requires and gets much more care. Air is such a common thing that many are inclined to regard machinery, in which air under compression figures, as requiring no attention. While it probably is the simplest form of power transmission, yet it must be looked after in order to secure any effective results. The air brake is simple and easy to operate. Still it must be kept in proper condition. A little knowledge of its operation and frequent inspection of its working parts will go a long way toward eliminating much of the trouble which has been reported.

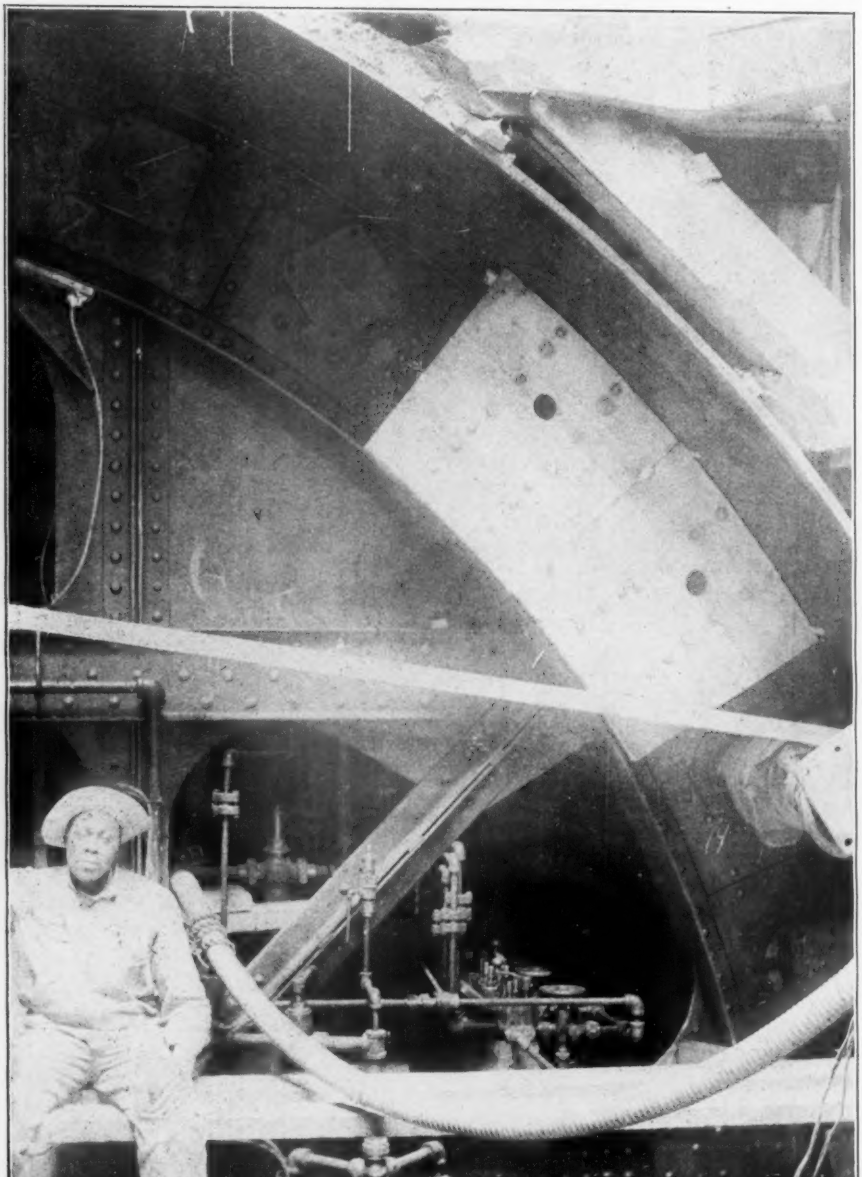
The East Boston Tunnel of the Boston Subway System.

On the 31st of December last the first train carrying passengers passed through the East Boston tunnel, thus marking the completion of a great project. The tunnel is a part of the Boston system of subways, and passes under the harbor, uniting, by a rapid transit line, Boston and East Boston. A brief resumé of the more important engineering features of the enterprise is appropriate at this time.

The act authorizing the building of the tunnel was signed June 10, 1897. The first contract was made in April of 1900 and active construction was begun very soon after. The completion of the tube has therefore required almost five years, during which a good average of daily progress has been maintained. Considering its magnitude, the work has been



SECTION C OF THE EAST BOSTON TUNNEL—UPPER AIR LOCK (LOOKING EASTERLY).



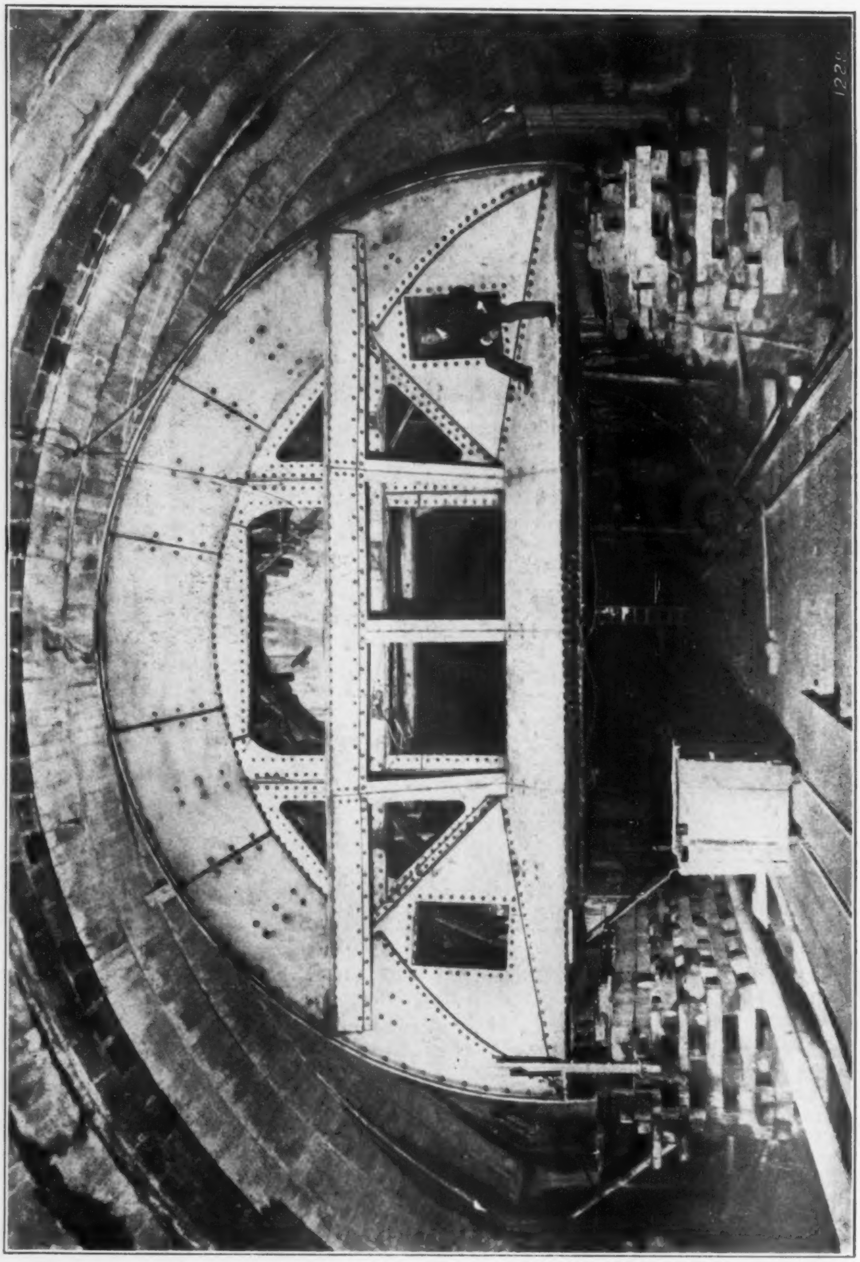
SECTION C OF THE EAST BOSTON TUNNEL—PORTION OF REAR OF ROOF SHIELD, SHOWING OPERATING VALVES AND TWO OF THE BULKHEADS ATTACHED TO THE PLUNGERS OF JACKS. (VIEW TAKEN AT EASTERLY SIDE OF SHAFT NEAR CUSTOM HOUSE.)

remarkably free from accidents and has been carried on with practically no injury to adjacent property.

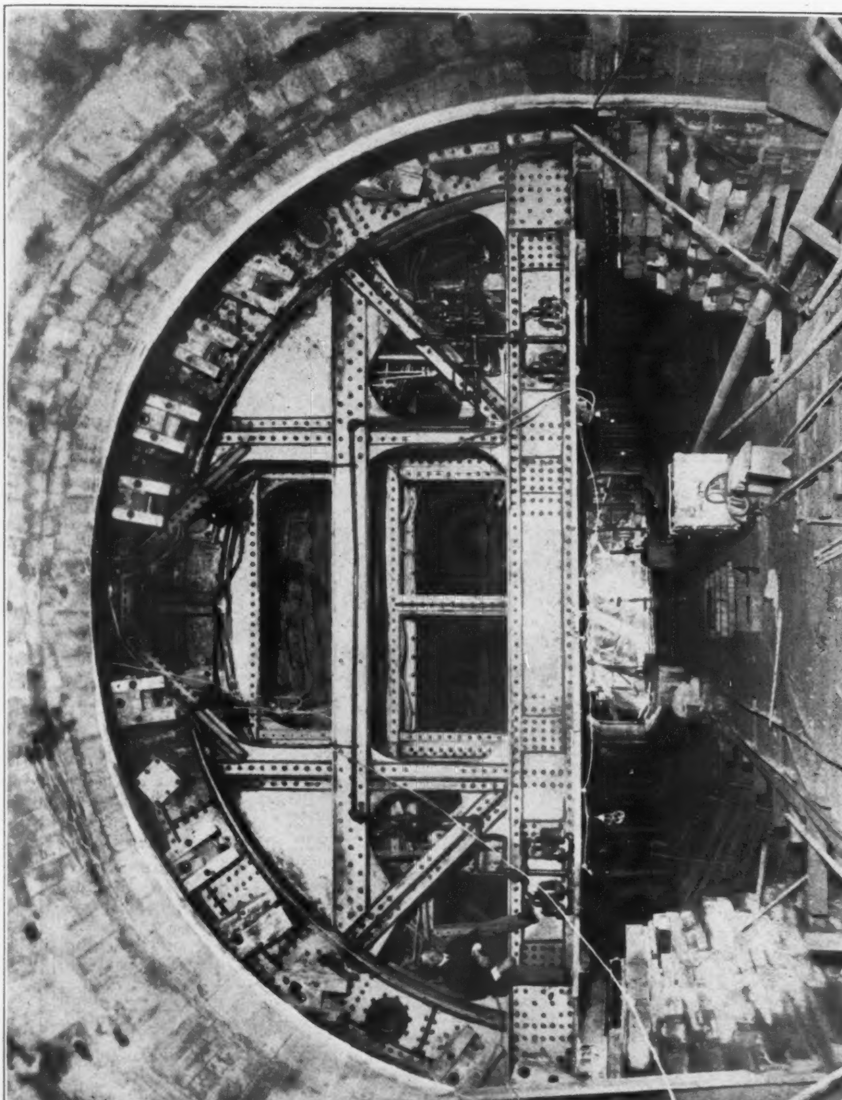
Sarting at Maverick Square, in East Boston, the tunnel passes under Lewis street, Boston Harbor, Long Wharf, State and Court streets to Scollay Square, in Boston, where connection is made with the Boston Subway. Three passenger stations are provided, located for most convenient connection with existing surface and elevated lines. The work, in part of its course, was pushed under some of the busiest streets of the city, yet there was little interference with traffic.

The total length of the tunnel is approximately 7,500 feet, of which fully two-thirds was built by the shield method, the remainder in open cut excavation. The portion of the bore actually under the water of the harbor is about 2,700 feet long, the balance of the tunneled portion passing through "made ground" filled in as the growth of the city demanded. Test bores were made along the line of the tunnel, so that the material to be penetrated were known in advance with reasonable accuracy. A depth greater than at present essential was demanded by the fact that allowance had to be made for possible dredging of the harbor to make a 40 foot channel. To meet this condition different grades were required in the tube. For the first 2,100 feet from Maverick Square the tunnel descends by a 5 per cent. grade; for the next 2,100 feet, reaching almost across the harbor, an ascending grade of 0.5 per cent. is maintained; then follows a length of 1,000 feet at 2.5 per cent., 1,800 feet at 4, 2.5 and 1.5 per cent., and the final rise on a 3 per cent. grade for perhaps 500 feet. The greatest depth attained by the tunnel invert is about 80 feet below mean low

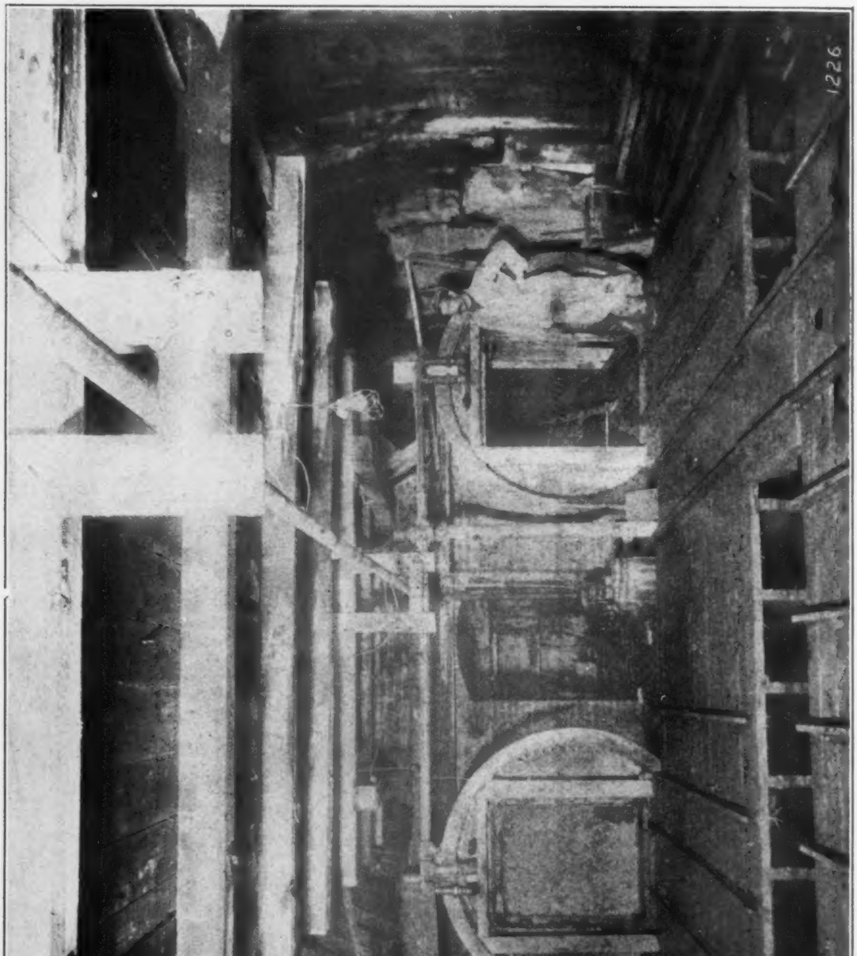
SECTION E OF THE EAST BOSTON TUNNEL—PLATFORMS (UNFINISHED) OF THE OLD STATE HOUSE STATION.



SECTION C OF THE EAST BOSTON TUNNEL—FRONT OR CUTTING END OF ROOF SHIELD. THE POSITION OF THE SHIELD IS WHERE ITS WORK WAS FINISHED. ALL EXCEPT THE REAR END IS UNDER THE LARGE ARCH OF THE PASSENGER STATION.



SECTION C OF THE EAST BOSTON TUNNEL—REAR OF ROOF SHIELD. THE ARCH SHOWN IS THAT OF THE NORMAL TUNNEL (LOOKING EASTERLY INTO STATION).



SECTION C OF THE EAST BOSTON TUNNEL—LOWER AIR LOCKS, ALSO TRACKS AND SHIFTING PLATFORMS FOR CONSTRUCTION CARS.

water. The least thickness of earth between tunnel and water is 18 feet. The cross-section of the completed structure varies at different points, but in general is the well-known horseshoe type. The bore is lined throughout with concrete, reinforced where necessary by steel rods bedded in. Ventilation is provided by powerful fan plants forcing fresh air from either end and electric lights illuminate the interior.

In construction the line was divided into six sections, lettered from A to F. Of these, Sections B and C were driven by straight tunnel methods; the other sections were built in open cut. The methods used in open cut were in general those of common practice; there were no novel features of striking interest. The streets were simply excavated to level and the concrete tube built in position, the timber framework being left in place for thirty days to allow the concrete to harden. The excavated material was then filled over all and normal surface conditions restored. This construction differed from that used in the New York Subway, in that concrete was used entirely instead of the steel structure adopted in New York.

Sections B and C aggregate 5,150 feet in length, and so form the major part of the contract. They are most interesting as having been constructed wholly by sub-surface tunneling methods. Section B, 4,400 feet long, was started at a shaft in Lewis street and was driven by the pneumatic shield method, almost the entire distance being made under air pressure. The air locks were three in number; the one near the top of the tunnel section being used almost exclusively by the men, the two lower ones giving exit to the excavated material. The side walls of the tunnel were built in advance of the shield in lateral headings. The roof shield, a heavy structure of steel work, was forced forward by powerful hydraulic jacks, being supported on rollers resting on plates on the walls. The air pressure required averaged about 22 pounds; the maximum was sometimes as high as 27 pounds. The volume of free air delivered to the headings averaged about 20 cubic feet per minute for each workman, and it was forced into both side drifts and above the shield, as well as in front of it. The compressing plant for this section included three Ingersoll-Sergeant air compressors; two low-pressure straight-line single-stage Class "A" machines furnishing air for the working chamber in the shield; and one high-pressure straight-line two-stage Class "AC" machine delivering air at a pressure of about 115 pounds. This high-pressure air was used in pumps operating the hydraulic jacks for moving the shield, developing a pressure of 4,000 pounds per square inch, applied in the sixteen jacks of 75 tons capacity each. This air was also used in driving motors running concrete mixers, winding engines and other devices; while a portion was discharged direct into the advance headings for ventilation. The combined free air capacity of these three compressors was something over 2,500 cubic feet per minute and they were driven by steam from a battery of three 100 horse-power boilers.

Section C, 750 feet in length, included that portion of th. line between Atlantic avenue and India street. The method of tunneling was in general that used in Section B, starting from a construction shaft near the Custom House. The shield used here was very similar to that in the other tunnel section and it was manipulated in the same manner. Three air locks gave access to the working chambers. The air pressure in front of the shield averaged about 18 pounds. The compressed air for this section was supplied by four Ingersoll-Sergeant steam-driven air compressors. Of these, two were straight-line high-pressure Class "AC" machines, having a combined capacity of about 1,500 cubic feet of free air per minute, delivered at 120 pounds pressure; the other two were low-pressure machines of straight-line Class "A" type, with an aggregate free air capacity of 2,300 cubic feet per minute, compressed to 40 pounds. The low pressure air gave ventilation and pressure in front of the shield; the high pressure air served as a motive power for pumps, winding engines and other appliances.

The total cost of the tunnel complete has exceeded three million dollars. The work was completed in the contemplated time and the methods of construction were found in every way satisfactory. The opening of this tunnel to traffic has reduced the time of transportation between Boston and East Boston by more than ten minutes and the improved facilities are far-reaching in their influences.

Commercial Possibilities of Liquid Air.

The question of the application of liquid air to useful purposes was not long ago actively brought before the public notice, not only through the medium of the press, but as the result of demonstration, both in the lecture room and in places of public entertainment. The result of this is to cause great misunderstanding as to the commercial value of liquid air, both as a source of power and as a refrigerant. A theoretical consideration of the principles involved and the energy absorbed by its production and subsequently set free by its volatilization and conversion to its original form of atmospheric air may therefore not be out of place.

In the first instance, it may be as well to enunciate the law on which Dr. Carl von Linde, of Munich, bases the action of his now well-known "Counter-current Interchanger (Gegenstrom-apparat)":—"When any so-called permanent gas is allowed to expand without the performance of external work, *e.g.*, through an orifice or porous plug, then, owing to the increase which takes place in its internal energy, the expanded gas possesses a temperature below that of the gas previous to expansion." As a matter of fact, the drop in temperature in the case of ordinary atmospheric air amounts to 0.24 deg. Cent. for every atmospheric difference of pressure.

This may be expressed by the formula—

$$D = 0.476\left\{\left(A - A_1\right)\left(\frac{493}{T_0}\right)^2\right\}.$$

Where D = reduction in temperature in deg. Fah.

T_0 = initial absolute temperature in deg. Fah.

A = pressure (in atmos.) before expansion.

A_1 = pressure (in atmos.) after expansion.

The actual amount of cooling produced by such expansion of a "permanent" gas appears to depend on the ratio of the specific heats at constant temperature and pressure respectively.

In the apparatus employed by Linde for the liquefaction of air, the value of A is fixed at 200 atmospheres, as this is found to give the most economical results in actual practice. Of course, such a limit is purely arbitrary, but in determining it due attention has to be paid to the fact that, while the work performed in compression is a function of and depends upon the value of the ratio

$$\frac{A}{A_1},$$

on the other hand, the actual cooling effect produced as the result of expansion varies directly with the value of the expression

$$A - A_1.$$

It will be obvious that the general efficiency of the apparatus employed varies with the capacity of output. Certain sources of loss remain practically constant, whatever the size of the installation, so that the larger the capacity of output the greater the efficiency. The following table is prepared from actual figures obtained with five different sizes of installation working under generally similar conditons:

Capacity Litres per Hour.	Actual Horse-power Required.	Brake Horse-power per Litre.
5	12	2.4
25	50	2.0
50	90	1.8
100	160	1.6
200	300	1.5

For the purpose of the present examination it will suffice if the average of the above figures be considered, so that the production of liquid air may be taken as about:—

1.86 horse-power per litre per hour.

i. e., 8.73 horse-power per gallon per hour.

Or, taking 0.93 as the specific weight of liquid air, as:—

0.78 horse-power per pound per hour.

Considering now the application of liquid air to the generation of power, in the first instance it is necessary to assume approximately the conditions, *i. e.*, temperature limits, under which a "liquid air engine" could be worked practically. Now it is obvious that, dealing with liquid air as water in a boiler, some source of heat other than the combustion of fuel is applicable for evaporating the liquid. The question then occurs at once as to whether it would not be possible to utilize the heat of the sun directly through the medium of the atmosphere of the earth for this purpose. Theoretically there is no objection to this, given a sufficiency of draught and surfaces large enough to transmit the

necessary heat with suitable rapidity. This, then, defines the value of T_1 in the expression

$$\frac{T_1 - T_2}{T_1}$$

for a perfect engine. So, therefore, T_1 may be taken as, say, 70 deg. Fah.

To obtain T_2, corresponding to the condenser temperature of a steam engine, suppose that a reduction of 20 deg. Fah. be possible so that $T_2 = 50$ deg. Fah., which may be taken as the average deep-well water temperature in this country. Now,

$$W = p_2 v_2 \log_\varepsilon \frac{v_2}{v_1},$$

where

W = work done in foot-pounds per pound of air.

p_2 = final pressure of air in pounds per square foot.

v_2 = final volume of 1 pound liquid air in cubic feet at the temperature of expansion (70 deg. Fah.).

v_1 = initial volume of 1 pound of liquid air.

$\frac{v_2}{v_1}$ = ratio of expansion from the liquid to the gaseous state at 70 deg. Fah. = 800 approximately.

From the above formula as basis is obtained the result that, theoretically, if 1 gallon of liquid air be evaporated and expanded in a perfect cylinder, it would be capable of developing about 1,900,000 foot-pounds, without allowing for losses.

Comparing this with the figures given above in connection with the power absorbed in production, the absurdity of the application is obvious.

It actually takes nine times as much power to produce 1 gallon of liquid air as can be, even theoretically, developed by 1 gallon of liquid air employed in a theoretically perfect engine.

As far as the application of liquid air to refrigerating purposes is concerned, this is equally impracticable. Take, for instance, the case of a small insulated cold chamber such as is used by butchers and provision dealers generally, and having a net cubical contents of, say, 800 cubic feet. To maintain such a cold chamber at a temperature of from 35 deg. Fah. to 40 deg. Fah., a refrigerating plant capable of eliminating about 9,000 B.T.U. per hour would be employed in ordinary practice. Such a plant on the ammonia compression system would require about 1½ brake horse-power to drive it, or if carbonic acid be the refrigerant employed, the power would be, perhaps, somewhat in excess of this, amounting to, say, 2 brake horse-power.

Now, according to Dr. Linde, in the case of liquid air, the total heat required to evaporate one pound of liquid air at atmospheric pressure, and to raise the temperature of the resultant vapor to 35 deg. Fah., is 342 B.T.U.

Consequently, assuming the application of liquid air to the above stated case of a butcher's safe, in order to approximate to what may be termed normal conditions of working, and assuming no source of loss, then to eliminate 9,000 B.T.U. per hour—the duty of the refrigerating plant in this case—a consumption of over 26 pounds of liquid air per working hour would be necessary. This corresponds to a power consumption of more than 20 brake horse-power, or more than ten times as much power as is required in the case of a carbonic acid machine for the same duty.

Moreover, apart from the extra power required to drive a liquid air refrigerating plant compared with a carbonic acid machine, the initial outlay in the former case is many times greater.

It must, however, be acknowledged that, notwithstanding the foregoing figures, there are great possibilities in the future for the application of liquid air to the arts. This is the more readily appreciated if it is borne in mind that by a very simple process of "fractionation," owing to the difference in the boiling points respectively of liquid nitrogen and oxygen, a gas which is practically pure oxygen (95—98 per cent.) can be obtained at a comparatively low cost. Furthermore, owing to this difference in the boiling points of the principal constituents of the atmosphere, liquid air as normally produced is actually much richer in oxygen than ordinary atmospheric air. This property renders it in certain cases particularly applicable to the following processes, among others:—

(1) *The manufacture of producer gas.*—In an article in *Chemische Industrie* Professor W. Hempel, of Dresden, describes the use in gas making of a mixture of half oxygen and half nitrogen, which is attained by liquefying air in a Linde machine, and allowing the liquid air to evaporate its nitrogen partly away. He states that the half-and-half mixture can be made at a working cost of 4d. per thou-

sand cubic feet by evaporating the remaining liquid, and it can be applied in two ways, either for making oxygen producer gas or oxygen water gas. In both of these gases the great advantages of internal heating are secured, but the heating values are relatively low, owing to the excess of nitrogen in the product. Producer gas is made, as is well known, by passing air through glowing coke to form CO—carbon monoxide—and N_2—nitrogen. If, however, instead of air, 50 per cent. oxygen be used, the results are considerably affected, as indicated in the following table:—

Constituents.	Ordinary Producer Gas. Volumes Equal Per Cent.	Oxygen Producer Gas.	
		Volumes.	Per Cent.
CO_2	3.4	3.4	6.1
Heavy hydrocarbons	0.8	0.8	1.4
O	0.3	0.3	0.5
CO	25.4	25.4	45.9
CH_4	5.3	5.3	10.7
H	6.8	6 8	12.3
N	57.4	12.7	23.0
	99.4	54.7	99.9

These results are only approximate, and would be affected by the nitrogen taken in along with the production of CO_2, but, on the other hand, the production of CO_2 would be diminished on account of the higher temperature in the producer.

(2) *The manufacture of water gas*, which is normally generated by passing a mixture of air and steam over glowing anthracite or coke, as in the Dowson process. Without going into details, it may be stated that a very great benefit is obtainable by the use of a 50 per cent. oxygen in place of ordinary air, as indicated by the figures in the following table:

Constituents.	Ordinary Water Gas.	Water Gas from 50 Per Cent. Oxygen.
H	12.1	25.3
CO	28.0	58.3
N	59.9	16.4

These figures are approximate, as in practice there would be some CO_2, but less marsh gas and ethylene.

(3) *The manufacture of explosives.*—When liquid air is brought into intimate contact with some easily oxidizable vehicle, such as coal dust or charcoal, the resultant mixture possesses the peculiar property of exploding with extreme violence by detonation. This method of blasting has actually been employed in the construction of the Simplon Tunnel. Under certain conditions it might prove extremely economical, and it is certainly safer than any other known method, as after a short period the liquid air has entirely evaporated and the cartridge is then quite inert.

(4) For illuminating purposes with incandescent mantles a great increase in candle power can be obtained. On a large scale it may be assumed that the cost of production per cubic foot is the same as that of a cubic foot of town gas, while the candle power obtained with a lamp such as the Nürnberg is increased from 1 with ordinary town gas to 5 with a mixture in equal parts, showing a net saving of 2½ to 1.

(5) The application of liquid air to the manufacture of calcium carbide, it is estimated, would in certain cases appreciably reduce the cost of production.

There are numerous other possible applications of liquid air to various industries, but first and foremost is its application to the cheap production of oxygen, as previously referred to, by fractionation. It is impossible to foretell what effect this may have in reference to the practical development of many processes in which oxygen is largely used at present, but it cannot fail to have great influence in many cases.—*The Engineer* (Eng.).

The Compressor Stuffing Box.*

The temperature of the water required for condensing purposes is governed by the change of season and atmospheric conditions. In some localities the rise and fall of this temperature climbs from a winter mark of 50 degrees Fahrenheit to a summer temperature of 80 degrees Fahrenheit and *vice versa*. In close relationship with the variable water temperature is the condensing pressure of the refrigerating medium. Each degree higher or lower the temperature of the condenser water asserts a positive influence upon the pressure required for the condensation of

*Continuation of a serial article by J. C. Goosmann, M. E., in the *Cold Storage and Ice Trade Journal*.

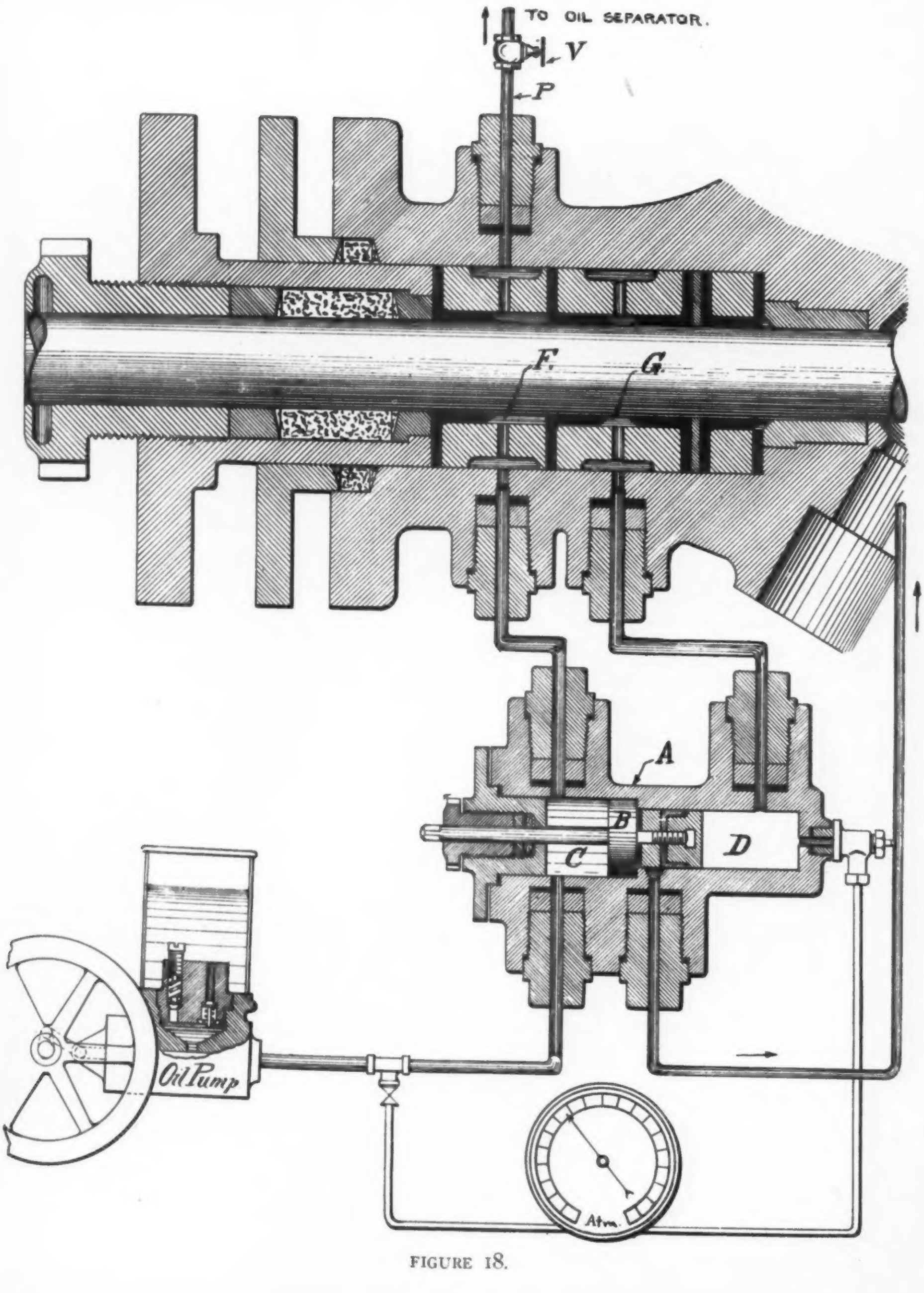


FIGURE 18.

the gas, and only the suction, or evaporating temperature, remains nearly constant throughout the year. In the foregoing chapter it has been shown that the success of the high-pressure stuffing box depends upon the gradual reduction by stages of the pressure within the same. The several sets of packing which divide the chambers must be subjected to a differential pressure only, a proper release of the leak gas must be provided before the latter asserts its tendency to escape through each successive set of packing, and a proper proportion of the high-compression pressure in relation to the leak-gas release pressure must be maintained. But as the high-compression pressure, and with the same the stuffing-box pressure, is subject to the change in the temperature of the condenser water it is desirable to use a stuffing-box pressure controlling device that can be varied in direct proportion with the higher or lower condenser pressure caused by a change in the temperature of the condenser water. It is further desirable that means should be provided to ascertain positively whether the correct pressures are maintained in the gas release, as well as in the oil chamber relative to each other and the high-pressure end of the cylinder, and finally the apparatus must be able to respond to these changes and maintain the required pressure at the will of the operator. After such means are employed it is easy to detect and trace defects in the packing or in the manipulation of stuffing box. Sedlacek's V-shaped release valve, Figure 17, in the January issue, assumes nearly the same high pressure for summer and winter operation, but as the high pressure takes quite a jump from the winter to the summer pressure, while the suction pressure remains about constant, the writer found it desirous to use a controlling device of sufficient flexibility to follow the change of pressure.

In case the device affords means to observe the pressure, as well as the occurrences, within the stuffing box during practical operation, the detection of a worn-out packing or an insufficient tightening of the glands is greatly accelerated, and acting upon this reasoning the writer designed a controlling apparatus for the above purposes which has been used successfully since. Figure 18 represents the stuffing box of a high pressure CO_2 compressor in connection with the same. The stuffing box is provided with gas release chamber *G*, and oil chamber *F*. Interspersed between these chambers are cupped leathers. The outer packing, *I*, consists of "Garlock" rings, which are held in the usual manner. Auxiliary cylinder *A* is connected to the stuffing-box chambers. Piston *B* of this cylinder divides same into two compartments, one of which, chamber *C*, contains the oil, while the other, *D*, forms a receptacle for the leak gas from the stuffing box. A lubricating pump forces the oil through *C* into chamber *F* at a fixed pressure. Pipe connection *P* with valve *V* conducts a small amount of oil with an occasional bubble of gas to the oil separator, which latter is interposed in the suction line of the system. Piston *B* acts as a valve to control the gas exhaust port leading to the suction valve chamber of the cylinder as shown.

We will assume that the highest pressure developed in the cylinder is 70 atmospheres and the oil pressure maintained is 30 atmospheres. The pressure exerted on the larger face of the piston will then equalize a pressure of 54 atmospheres on the smaller area of piston *B*. Hence when the pressure of the escaping gas in the stuffing-box chamber *G* exceeds 54 atmospheres the piston will be moved to uncover the gas exhaust and permit the gas to return into the suction port of the cylinder in an obvious manner. It will readily be seen that any variation of the oil pressure reacts upon the gas release pressure in the proportion of the larger area to the smaller area of piston *B*. Should the first set of packing be worn out piston *B* will release the leak gas frequently. This will also take place in the case that the stuffing-box gland is not sufficiently drawn up.

The above apparatus operates very reliably, but it complicates the immediate surroundings of the stuffing box. It has also the disadvantage of being dependent upon the oil pressure, and it is necessary to regulate the oil pressure by means of valve *V*, so as to maintain a fixed gas release pressure.

Another device of the writer's design simplifies matters considerably without surrendering any of the desirable points enumerated above. It has no connection with the oil pressure, so that it may be automatically controlled by the suction gas pressure. It is simple, requires few connections and operates very efficiently. Figure 19 illustrates this improved controlling apparatus. The stuffing box is again provided with gas chamber *G* and

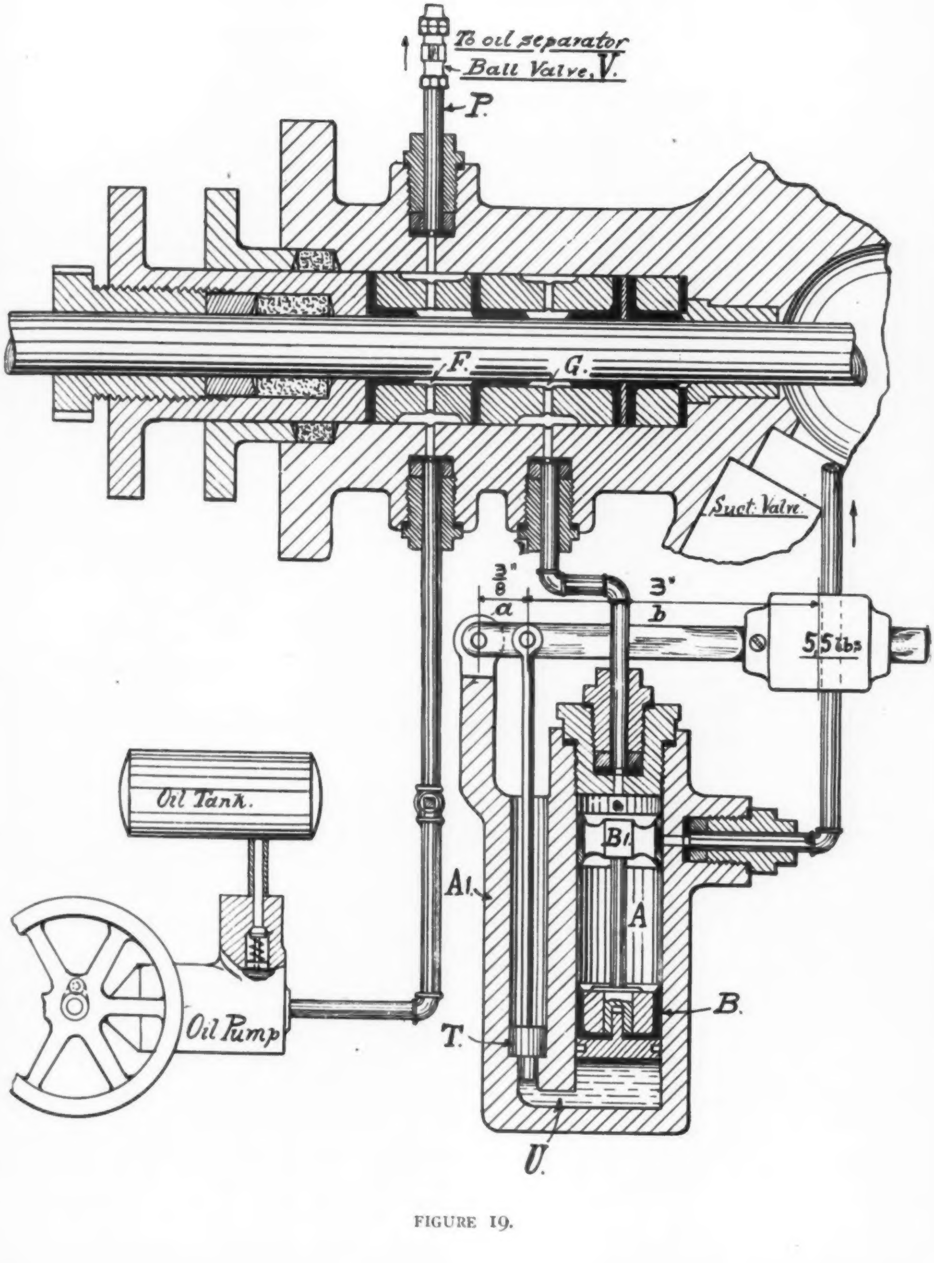

To oil separator
Ball Valve, V.
P.
F.
G.
Suct. Valve.
3/8"
a
3"
b
55 lbs
Oil Tank.
B1
A1.
A
B.
Oil Pump
T.
U.

FIGURE 19.

oil chamber *F*, which is fed by the automatical operating oil pump as shown. Pipe connection *P*, with ball valve *V* leads to the oil separator of the suction line so that the oil pressure in oil chamber *F* is constantly slightly superior to the suction pressure. Auxiliary cylinder *A* is connected to gas chamber *G* of the stuffing box by means of a small pipe. Piston *B*, with hollow trunk valve *B* controls the gas exhaust port leading to the suction valve chamber. Adjacent to cylinder *A* is a small cylinder *A1*, in which a piston *T* is movable. Both cylinders are connected by means of a passage *U*, which, together with the lower end of cylinder *A*, is filled with a heavy liquid. The piston rod of piston *T* is weighted down by means of a lever carrying an adjustable weight on its free end. In place of this weight a spring may be used. The leak gas collects in chamber *G*, and as soon as a pressure about 15 atmospheres lower than the high pressure is reached, it forces piston *B* to recede until trunk valve *B1* uncovers the gas exhaust port and the leak gas escapes into the suction port. It is clear that by adjusting the weight, or the tension of a spring attached to the free end of the lever, any fixed release pressure may be maintained. The adjustment of the weight for certain release pressures may be calibered on the lever and calculations to ascertain the correctness of the adjustment may be easily made if the dimensions of the acting parts are known. For instance, if a high pressure of 65 atmospheres is required, the release mechanism should be adjusted for a pressure of 50 atmospheres. We will assume a diameter of piston *B* of one inch and of piston *T* of one-quarter inch. Distance *a* is fixed at three-eighths inch and the weight as well as the distance *b*, at which same is to be set is determined by the following example:—1″ diam. = 0.78 area; ¼″ diam. = 0.05 area; $0.05 \div 0.78 = 50$ atm. $\div X$; $X = \frac{0.78}{0.05} = 1 \div 16$; $0.78 \div 16 = 0.05 \div \frac{50 \text{ atm.}}{16} = 3$ atm. $= 44.1$ lbs.; $a \div b = \frac{3''}{8} \div 3'' = \frac{3}{8} \div \frac{24}{8} = 1 \div 8 = \frac{44.1}{8} = 5.5$ lbs. hence it requires the weight of 5.5 pounds at a distance of 3 inches to release a leak pressure of 50 atmospheres. It is essential that a relatively high pressure should be maintained in chamber *G*, for the reason that this serves in itself to prevent excessive gas leakage, and it also prevents the excessive flow of oil which might otherwise find its way into the cylinder, so that the oil in one chamber and the leak gas in the other chamber serve as checks on each other, the oil seal serving to prevent escape of gas and the gas seal likewise serving to prevent an excess of oil entering the cylinder. The small amount of gas which may be carried into the oil chamber *F* escapes with a small amount of oil into the oil separator, so that in reality the leak gas is released twice; first, from chamber *G* to the suction port at a pressure of 15 atmospheres below the high pressure, and next, from oil chamber *F* at a pressure slightly above the suction pressure to the oil separator.

So long as the packing remains intact it is impossible to observe even the very slightest gas leakage on the outer end of the stuffing box when this device is used. As soon as the packing wears out the operator is notified immediately by the action of the controlling apparatus. The glands must then be taken up, and if that does not remedy the defect the packing must be renewed.

The latest invention designed for the purpose of preventing gas leakage in high-pressure compressors is shown in Figure 20. George Braungart, Jr., is the inventor. Attached to the two chambers of the stuffing box is an oil-pressure device. Chamber *G* constitutes the leak gas and *F* the oil receptacle as usual. An auxiliary cylinder, *A*, is secured to the stuffing box and has its heads connected respectively with the oil and leak gas chamber of the latter. A piston, *B*, of differential diameter, is slidably mounted within the cylinder and is provided with cupped leathers on each end.

A pressure gauge records the oil pressure exerted by the oil pump. As soon as the pressure of the leak gas rises it tends to force piston *B* into the oil chamber of cylinder *A*, thereby increasing the oil pressure. In this way the leak gas forces the oil to seal more effectually the passage through the stuffing box. On the suction stroke a small amount of gas is supposed

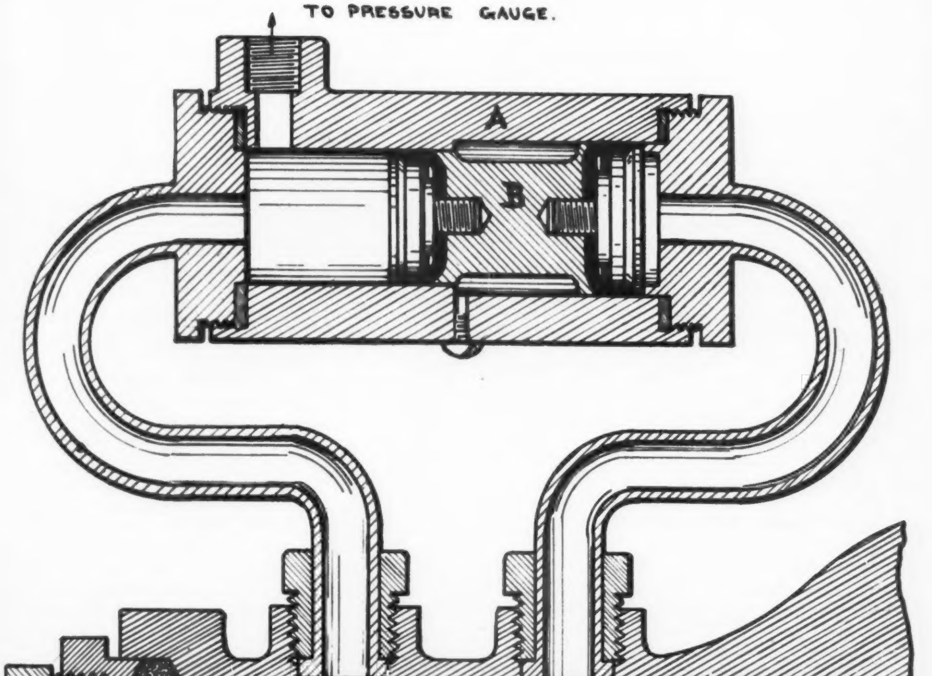


FIGURE 20.

to leak back into the cylinder to relieve the tension.

The inventor has dropped the idea of an actual gas release apparently, but as practice has shown that such release cannot be dispensed with, it stands to reason that the increased leak-gas pressure will eventually procure a passage through the remainder of the stuffing box and finally escape at the outer end. On the other hand, if the first set of packing allows a comparatively free leakage of gas from the cylinder into chamber *G*, and from *G* back into the cylinder, this part of the stuffing box will soon become hot and destroy the packing. In addition there are other important reasons which eliminate the possibility of the practical utility of the construction. The writer doubts the practical success of any high-pressure stuffing box constructed on the theory of a check of the oil pressure on the gas and the gas pressure on the oil alone. The leak gas, which will inevitably pass into the stuffing box, no matter how efficient the packing may be, must be released from time to time, and it is up to the constructor to employ such means as are likely to reduce this leakage to a minimum. These means consist chiefly of a first-class, well-proportioned piston rod in connection with the most suitable packing as well as lubrication.

Air-Lift Pumping Plant of the Redlands Water Co.

A test was recently conducted on an air-lift pumping plant in the irrigation works of the Redlands Water Co., Redlands, Cal., to determine its efficiency. The works supply water to about 1,000 acres of land, practically all of which is set out in orange groves. The supply was formerly obtained from the Bear Valley irrigation system, but during three months in the summer this system was unable to furnish water, and deep wells were sunk to afford a supply to cover the deficiency. The part of the works at the pumping plant before the installation of the air-lift system embraced four wells from 415 to 570 feet deep, a boiler and engine house, a receiving basin and a storage reservoir. One of the wells was operated by a centrifugal pump driven by an electric motor, one by a plunger pump driven by an auxiliary steam engine, the third by a centrifugal pump driven by a steam engine, while the fourth was not in use. It was decided to replace these pumps and machinery by some system which would be adapted to the varying heights of the ground-water level and at the same time could be applied from one plant to all four wells, which are 50 to 150 feet from the central point.

The wells are sunk through strata of clay and gravel, which are very irregular in formation, the clay being encountered in pockets of varying thickness and at various elevations in the different wells. It was determined that the greater part of the supply was drawn from the upper part of the wells, and when the three that were in operation were being drawn upon at the usual rate the ground water-level, which usually stood within about 45 feet of the surface, was drawn down from 20 to 25 feet. A drainage area of 1.54 square miles is immediately tributary to the wells, and it was considered that, if this local drainage basin alone supplies the wells, the present rate of extraction would lower the water plane. The depth of the ground water below the surface and the draft upon it is also dependent to a considerable extent upon the yearly variation of rainfall. Any system to be installed was required to be sufficiently flexible to meet the varying heights of suction lift.

The installation of a reciprocating steam pumping plant was not feasible, as the sinking of a large pump shaft connected to the various wells by tunnels was held to be comparatively impracticable, owing to the gravelly nature of the soil and to the proximity of the tunnels to the storage reservoir. There was also liability, in case the shaft was sunk and the tunnels run, of the water plane afterward dropping below the proper suction lift of the pump. In this event, although the shaft and pump might be lowered, the tunnels could not be conveniently lowered.

While electrically-driven centrifugal pumps are adapted to conditions similar to those of this plant, the local high cost of electric power prevented their installation. Power cost 2.5 cents per horse-power-hour for the motor that was already in operation, making the cost per water horse-power-hour between 5 and 7 cents, depending on the efficiency of the pump. The separate engine required at each well by steam-driven centrifugal

pumps was undesirable, and the high cost of fuel for a gas-engine plant made such an installation impracticable.

An air-lift system operated by a central compressor plant was considered to afford the most economical means of meeting the situation, so the wells were fitted with air and discharge pipes, and a complete compressor plant installed. The discharge pipes vary from 4 to 7 inches in diameter and extend from 306 to 360 feet down in the wells. The air pipes, from 1¼ to 2 inches in diameter, reach down from 300 to 312 feet inside the discharge pipes. The plant is placed in a 40 by 46 feet, one-story brick engine house, with a corrugated iron roof. A 16 by 5½ feet oil-burning horizontal tubular boiler, made by the Murray Iron Works, of Burlington, Ia., supplies steam to the air compressor, made by the same company. It is a cross-compound Corliss compressor, with a 13-inch high-pressure steam cylinder, a 14-inch high-pressure air cylinder, a 26-inch low-pressure steam cylinder and a 22-inch low-pressure air cylinder, all with a 30-inch stroke. The machine was designed to develop 190 indicated horse power when running at 85 revolutions per minute and ¼ cut-off, steam being supplied at 125 pounds, and the engine operating condensing. Under these same conditions the compressor has a guaranteed capacity of 1,124 cubic feet of free air per minute compressed to 125 pounds, which is equivalent to 938.83 cubic feet per minute, when the compressor is operating at 71 revolutions per minute, the normal rate of operation. The air receiver is 3 feet in diameter and 8 feet long, with shell plates ¼ inch thick and heads ¾ inch thick.

A 2½ by 4-inch Smith-Vaile triplex pump and a 4½ by 3 by 4-inch Smith-Vaile duplex pump furnish water to the boiler. It is placed in a compartment beside the receiving basin. The wells discharge into this compartment, and the water flows from it over a weir to the basin. The condenser consists of small brass pipes, with about 300 square feet of cooling surface, and as it is always submerged when the plant is in operation, it forms a surface condenser without the usual cast-iron shell. A 6½ by 10-inch belt-driven vacuum pump is operated in connection with it. An inclosed exhaust-steam feed-water heater is placed in the exhaust main of the engine, and a hot well is also provided. The boiler is placed on concrete settings and all the machinery was set on concrete foundations.

The test was conducted for 48 hours a few days after the machinery was in place, with normal conditions of operation, the object of the test being to determine the amount of fuel used in each 24 hours when lifting and discharging certain quantities of water, and not drawing the water plane below certain elevations. The engine was run at 71 revolutions per minute, but toward the end of the test the speed was increased to 76 revolutions per minute for 33 minutes, with a corresponding increase in flow of about 100 gallons per minute. Crude California oil was used in the burners under the boilers. The quantity of oil consumed was measured by noting the fall in two large storage tanks, whose capacity had been accurately determined. The flow of water was measured by a weir in the concrete wall between the discharge compartment and the receiving basin, and checked by noting the height of water in the basin, the quantity per

Table of Conditions Existing During 48-Hour Test on Air-Lift Pumping Plant of the Redlands Water Co., Redlands, Cal.

Pressure.	Maximum.	Mean of 48 Hourly Observations.	Minimum.
Boiler, lb. per sq. in.	150.0	146.7	142.0
Air, comp. gauge, lb. per sq. in.	94.0	90.98	85.0
Steam, in receiver, lb. per sq. in.	14.5	12.45	11.0
Air, intercooler, lb. per sq. in.	20.0	19.3	19.0
Vacuum, in. of mercury	25.25	24.83	24.5
Well No. 1:			
Air pressure, lb. per sq. in.	89.0	87.4	84.0
Water, below surface, ft.	109.0	101.44	98.0
Well No. 2:			
Air pressure, lb. per sq. in.	95.0	93.6	92.0
Water below surface, ft.	93.0	90.37	86.0
Well No. 3:			
Air pressure, lb. per sq. in.	90.0	87.08	85.0
Water, below surface, ft.	116.0	110.67	99.0
Well No. 4:			
Air pressure, lb. per sq. in.	86.0	85.4	84.0
Water, below surface, ft.	105.0	102.2	101.0
Fuel consumption, bbl. pr. 24 hrs.	17.2	16.3	15.7

Rate of pumping, gal. per 24 hrs—Maximum, 3,280,824; mean of 48 hourly observations, 3,157,622; minimum, 3,131,395.

foot of depth in it having been previously obtained.

The accompanying table gives the results of the test, only the maximum, minimum and mean values of 48 hourly observations being given. As may be seen from the table, the range of values in all cases was comparatively slight, the arrangement of the plant permitting unusually uniform conditions to be maintained. The test was conducted by Mr. T. S. Smith, as engineer for the Pacific Coast Manufacturing Co., the firm which furnished and installed the machinery; Mr. O. K. Parker, as representative for Mr. J. B. Lippincott, consulting engineer, of Los Angeles, and Mr. James N. Clark, superintendent of the Redlands Water Co.—*Engineering Record.*

Experience with Storage Air-Brakes at St. Louis.

The storage air-brake system has been in operation on most of the cars of the United Railways Company, of St. Louis, since before the opening of the World's Fair. This being the first large street railway to be equipped with the storage air-brake system, considerable interest attaches to the performance of the storage air apparatus in actual service. It was thought by some that the compressing stations might be a source of trouble in cold weather, as they are expected to run without an attendant on duty all the time. No trouble has been experienced on this score. An attendant visits each station every two hours. The heat liberated by the compression of the air is not sufficient to heat the compressing station in the cold weather and stoves have been put in the stations, which are looked after by the attendant on his regular visits.

Almost the only difficulty experienced so far in the practical operation of the system is that the reducing valves on the cars have sometimes frozen up. The main storage tanks under a car carry air at 300 pounds pressure. Air is fed through a reducing valve to the service reservoir from which the brakes are operated. The latter reservoir is kept at 45 pounds pressure. If the reducing valve is frozen it may result in allowing an abnormal pressure in the small service reservoir and the blowing of the pop valve in this reservoir. A frozen reducing valve can be thawed out by burning a newspaper or something similar under the valve. On one line the reducing valves have been taken from under the car and put inside the car under a seat. This does away with the trouble.

Another improvement made has been in the introduction of blow-off cocks on both the high and low-pressure storage tanks on the car, by which the water can be blown out. The original plans called for these cocks, but in the hurry of equipping the cars before the opening of the World's Fair, the blow-off cocks were omitted in most cases and plugs were inserted. It is the intention to remove these plugs and put in blow-off cocks on all the cars, which will make it possible to drain off the moisture several times a day if necessary. As with any compressed-air apparatus, the most trouble from freezing comes when warm, moist weather is followed by a cold wave.—*Street Railway Journal.*

Small Compressed Air Plants for the Small Monument Shop.*

The rapid development of the use of compressed air in the stoneworking field has made it essential for all concerns, no matter how small, to install pneumatic tools in order that the work turned out may be done not only as economically, but as well as that of competitors. It is a well known fact that, aside from the matter of economy, carving and lettering done by pneumatic tools is cleaner and better, and handwork suffers in comparison with it. So rapid has been the improvement in compressed air machinery that to-day a granite and marble concern can equip a plant for even one pneumatic tool that will cost no more, proportionately, per tool, to install and maintain than the largest plants in Barre and Quincy. The writer has in mind a pneumatic plant consisting of an electric motor, air compressor, receiving tank and one pneumatic tool, which cost less than one hundred and sixty dollars; and it is as efficient and durable as an air plant can be made.

The owner of a pneumatic plant figures in actual practice that he is getting his lettering and carving done at from 30 to 40 per cent. cheaper than he formerly did it by hand, depending on the pro-

*Extracts from an article appearing in *The Reporter*

ficiency of the workman. Sellers of pneumatic machinery may sometimes make the claim that with an equipment of tools the work turned out in a shop will be doubled; but while it certainly is accelerated to about the percentage above stated, when it comes to doubling the actual amount of work done day in and day out, it may not be quite as rosy as the enthusiastic seller of tools claims. While a man with pneumatic tools may be able to cut two letters to the hand workman's one, on a special trial spurt, it must be remembered that there is no gain in the time consumed in laying out the work, moving the stones, lighting pipes or taking chews of tobacco; so that the actual average superiority will be found around 30 to 40 per cent. But this is enough to make it pay.

The man who got along with one letterer, occasionally turning in himself and cutting an inscription when the rush was on, has generally hesitated about putting in pneumatic tools on account of the first cost and the continual cost for maintenance and power. The first cost of the plant was anywhere around $300 to $600, the power a dollar a day and repairs and oil about $15 to $25 per year, so that interest on the extra expenditure would pay the wages of an extra man three or four weeks during the busy time, and cause the proprietor to hesitate a long time before putting in the money.

The cost at which a one-tool plant may now be put in, makes it an absolute waste of money not to have it; the advertising feature alone, in a small town especially, making up for all the interest on investment. The boss can spend his extra time hustling about for more business.

In figuring how much power is required to operate one or more pneumatic tools, a good rule to follow, providing the compressor is made suitable for the power, is one horse-power for each tool used. Even this consumption can be reduced a little if the proper compressor is installed.

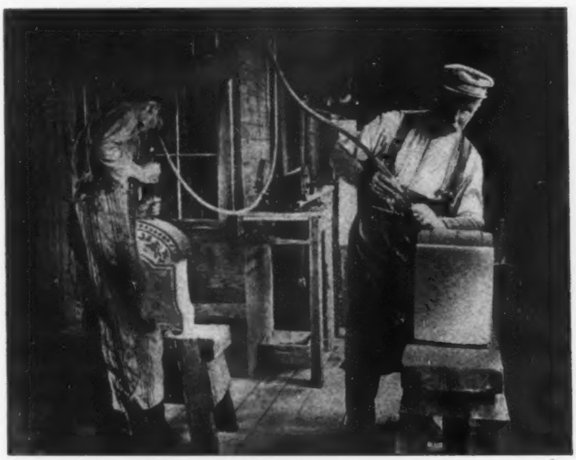


ILLUSTRATION NO. I.

Exhaustive tables may be consulted, showing the number of cubic feet of free air consumed per tool per minute, and the number produced by a certain compressor with a certain power back of it, but they will all be found to work out to about the one-horse-power-per-tool basis when it comes to actual work in the average shop with the average tool.

The principal item for consideration in the installation of a small pneumatic plant is the power, for on this depends the success of the plant, and the selection of the proper power must depend on local conditions. Electricity, of course, is the

most convenient where it can be had all day and where its cost is at all reasonable. The local electric companies will usually attend to the installation of the motor and its maintenance without charge, in some cases even furnishing the motor free or at a nominal rental; and this freedom from responsibility on the part of the owner is of considerable importance. In most cities and towns the cost of electricity is quite reasonable, and even if slightly in excess of other kinds of power, in the long run it is the most economical. Besides, the first cost of the motor is considerably less than a gas or gasoline engine, and liability of accident, failure and consequent loss much less.

The gas engine to-day is more generally used than any other power, the fuel being either gas or gasoline. And they are available in even the most isolated locations, for towns where there may be no electric service, or in cases where the shop is located at a cemetery, a mile or so away from the nearest terminal of the electric service. There are many good makes of gas engines and many more poor ones, and first cost in a gas engine should be the last consideration. A good gas engine properly installed will cost very little to operate. For instance, a marble and granite works in Massachusetts has an 8 horse-power gas engine which operates a six-tool compressor, rubbing bed and grindstone continuously nine hours a day, and with dollar gas costs less than 90 cents per day to operate the plant. A good gasoline engine will cost about the same, both for first cost and subsequent maintenance.

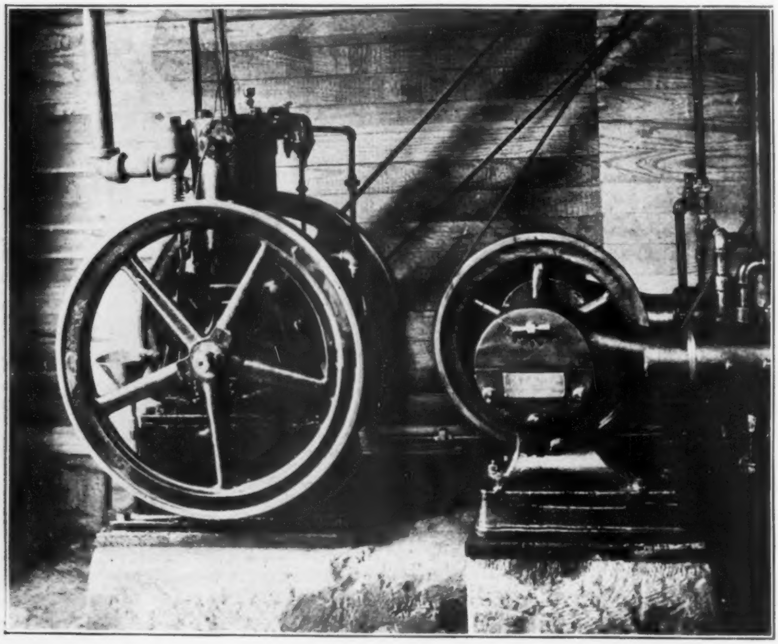


ILLUSTRATION NO. 2.

Considerable improvement has been made in kerosene engines during the past several years, although the writer

has no actual data of performance at his command, but there is no reason why a kerosene engine should not be used extensively, as kerosene is a cheap, safe fuel and does not evaporate like gasoline.

In installing a gasoline engine care should be taken to inquire into the insurance regulations governing in the locality where it is to be used, as in many places these require that all supply of gasoline be kept outside the building insured, unless the engine be so constructed that the liquid is contained in the cast-iron bed of the engine, as in some makes. The oil engine is not subject to these requirements.

In the selection of a compressor and power to operate it, the possibility of future requirements must be taken into consideration, for it is always expensive to discard a compressor that has grown too small and purchase a larger one. It is also well to inquire thoroughly into the construction and efficiency of the many types offered for sale. A stone yard is not an ideal place for the operation of machinery of this kind, as grit and dust is ever present, and is liable to get into the wearing parts of the machinery and do great injury.

If a compressor is installed that has the bearings exposed, as in the ordinary steam engine, it is almost a necessity that it be housed, in company with the gas engine that drives it, in a separate, practically dust-proof room, or a sort of large cupboard-like space may be partitioned off in one corner of the shop, fitted with glass so that the machinery can be kept under observation from time to time without going in. Where a motor and belt-driven compressor are used, the motor can often be set on a stout platform built up near the ceiling, with the compressor under it and the tank in any convenient place—sometimes laid on brackets up near the ceiling or stood in a corner of the cutting shop itself. Never buy a compressor because it is cheap, and be extremely wary of second-hand machinery unless it is positively known to be in first-class condition; though sometimes good bargains may be picked up in this way. The profit in an air plant is in the economy of maintenance and its uninterrupted operation, though even if it stood idle the rest

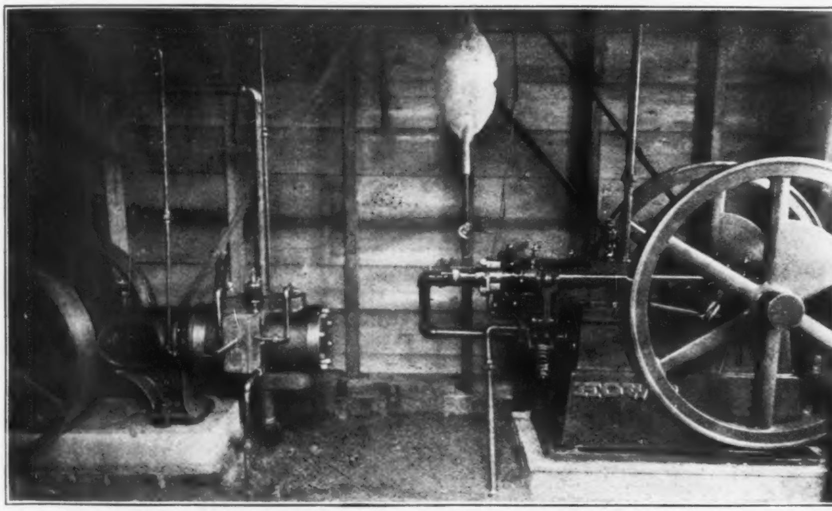


ILLUSTRATION NO. 3.

of the year, the small plant will pay good returns in the busy time around Decoration Day.

on and has used since; and competition has brought the prices down to where they are very reasonable indeed.

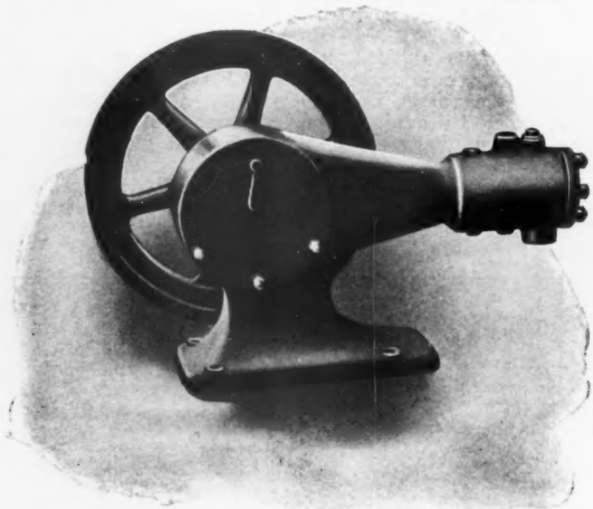


ILLUSTRATION NO. 4.

There are now quite a number of excellent makes of pneumatic tools offered for sale, their choice depending mostly on the opinion of the men who are to operate them, the only tool on earth, to the workman, being the one he learned

Illustrations Nos. 1 and 2 show a plant consisting of a 3 horse-power gasoline engine, a 4 by 5 inclosed self-oiling compressor and two pneumatic tools. The owner of this plant proudly says that people tell him he has the finest equipped

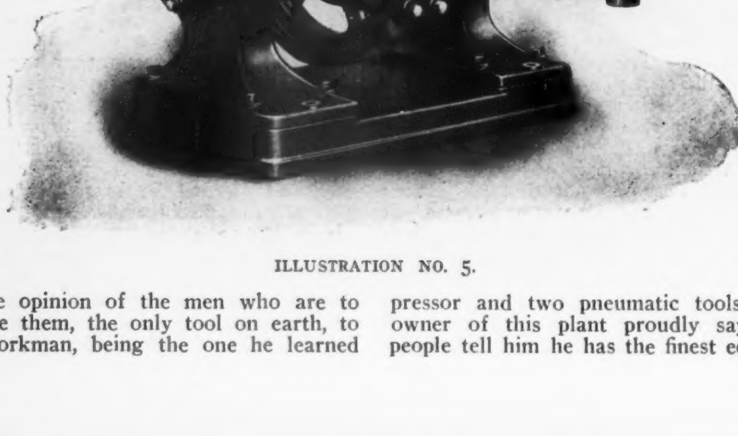


ILLUSTRATION NO. 5.

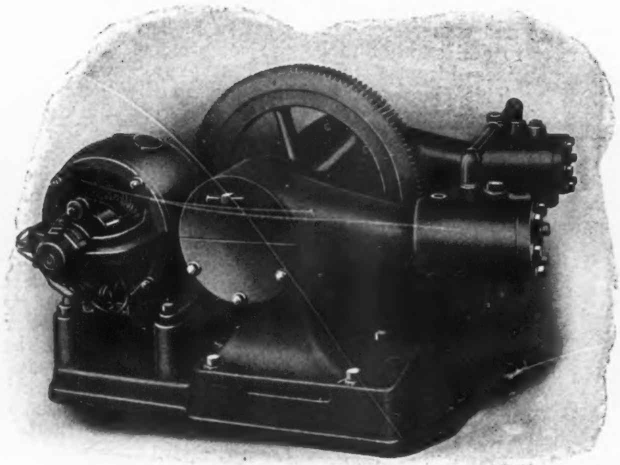


ILLUSTRATION NO. 6.

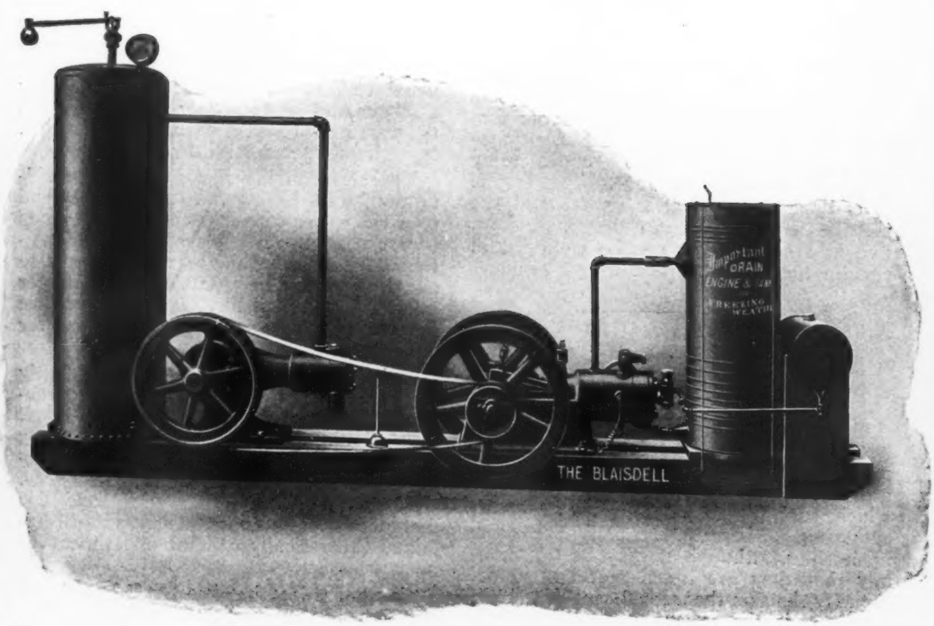


ILLUSTRATION NO. 7.

pneumatic plant for its size in the country. Both the engine and compressor are of sufficient capacity to add another tool should the owner's business increase sufficiently to require it. This plant cost in the neighborhood of three hundred and twenty-five dollars, and it is certainly a model one.

Illustration No. 3 shows a 5 horse-power gas engine and a 6 by 6 compressor, having a capacity of five pneumatic tools.

Illustration No. 4 shows a single, self-oiling compressor of capacity for one to three pneumatic tools. This compressor has been designed especially for this service.

Illustration No. 5 shows a duplex, self-oiling compressor, made in sizes from two to eight tools capacity. It is mounted on a heavy sub-base, necessitating only a very inexpensive foundation.

Illustration No. 6 shows a duplex, self-oiling compressor direct connected to a motor.

Illustration No. 7 covers a plant consisting of a 3 horse-power gas or gasoline engine, compressor of sufficient capacity for two or three tools. To operate this plant continuously at full capacity requires three pints of gasoline per hour. The engine is equipped with a very efficient fuel governor and with intermittent service, as is the case with pneumatic tool work in the small shop, the fuel consumption actually runs considerably under three pints per hour. The engine is equipped with electric igniter and the plant as a whole is a model one. A four, five or six-tool plant can be equipped in exactly the same manner.

Air Consumption in Machine Drills.

One frequently hears the expression, "20-drill," "50-drill," "60-drill" air compressor, and other varying terms which are taken to express the number of drills which such a compressor is capable of actuating. These expressions are quite misleading, although it may be occasionally that they are based more on actual capacity than on theoretical capacity. This, however, is the exception. But there is one gratifying thing about the misleading expressions, and that is that the estimates of air drills thus given is always lower instead of higher than the actual capacity of the compressor.

These expressions, by means of which it is attempted to describe the capacity of an air compressor, are generally based on the old theory that it requires 100 cubic feet of air to actuate an air drill for one minute. On this basis a compressor supplying 2,000 cubic feet of air in one minute would be called a 20-drill compressor, 3,000 cubic feet a 30-drill compressor, 5,000 cubic feet a 50-drill compressor, 6,000 cubic feet a 60-drill compressor, and so on.

Continuous Michigan copper country practice, however, has demonstrated that it does not require more than three-quarters of that amount of air to actuate an air drill in the rock which is mined here. Naturally the conditions always depend upon the efficiency of the system supplying the air, and particularly upon the amount of leakage in the pipes. But with the alert mining captains on guard all the time, these leakages are generally at a minimum.

At one test which was made in a copper country mine over a continuous period, so that all normal conditions could be taken into the calculations, it was found that the air drills each required 66 cubic feet of air per minute. It is quite likely, however, that when this test was being made unusual vigilance was exercised in keeping all leaks and waste as low as possible, and the test may be said to have been made, in a measure, under ideal conditions.

Therefore, taking all things into consideration, and letting the average extend over the entire copper country, in all kinds of rock and in all kinds of mining conditions, the average figure may be said to stand very close to 75 cubic feet of air per minute for each drill. Generally practice demonstrates that this figure is not far from correct.

It is quite natural, with the constantly increasing economy which is being practiced, and the constant betterment in all lines of mining practices, air drilling along with the rest, that the amount of air required to actuate a drill should be reduced. And therefore the standard of 100 cubic feet of air per minute, which is still retained theoretically, was at one time very nearly correct.

Another thing that has tended to throw out the old standard and establish a new one is the great increase in the capacity of the compressors. Take a small com-

pressor, even to-day, and the old standard will be much closer to the correct one than the new. Therefore, since small compressors were the rule rather than the exception in the earlier days, while nowadays one does not often see a compressor in a regular producing mine with a capacity of less than 2,000 cubic feet of air per minute, it is easy to understand that the introduction of large compressors has effected a gradual reduction in the amount of air required per drill.

For example, a small compressor with a capacity of, say, 300 cubic feet of air per minute would not be capable of actuating probably more than two drills, since the general losses would be almost as heavy as in a compressor with a capacity of ten times that amount of air. This estimate is only an approximation, but assuming it to be correct, the loss through leakage and other causes in the compressor would be, say, 100 cubic feet of air per minute. This loss would be cut off one drill in a 300-cubic-foot compressor, and thus reduce its capacity one-third. But it would also cut off only 100 cubic feet of air per minute in a 2,000-cubic-foot compressor and reduce its capacity by such loss only one-twentieth. So when the capacity of the compressor is gradually increased to 3,000, 5,000, 6,000 and even 10,000 cubic feet of air per minute, as is the case in a number of air compressors in the copper country, the loss by leakage and other cause is seen to become almost infinitesimal in proportion to the amount of air compressed.

Therefore it need not be surprising to read frequently of a compressor rated at 60 drills carrying probably 75 or 80 drills. An understanding of this misconception may set many people right who formerly could not see how a compressor could run so far above its rated capacity.

An interesting story is told of two manufacturing houses which went into competition for the erection of an air compressor in the copper country about four years ago. This compressor was to actuate a given number of drills. One of the houses understood the requirements of a copper country air drill, and was figuring its compressor on the basis of 75 cubic feet of air per minute for each drill. The other house held to the old standard of 100 cubic feet of air per minute, since at that time the reduced consumption in the copper country had not become generally known, and is in fact to-day known only to those professionaly engaged in lines which have brought it to their attention.

Hence when the bids were opened there was a wide discrepancy in the estimated cost of erecting the compressor by the two companies. This occasioned some surprise on the part of the mine management, but when the details were looked over it was discovered that the higher priced competitor had figured on much larger air compressing capacity than the lower priced competitor. The management, seeing this difference, did a little figuring itself, and as a result came to the conclusion that the higher priced people were giving more for their money than the lower priced people. Therefore all bids were rejected and new bids were called for on the basis of a compressor which would supply a given number of cubic feet per minute instead of a compressor which would actuate a given number of drills. The result of the second competition was an underbidding on the part of the formerly high priced people, which landed the contract.—*Mining Gazette* (Houghton, Mich.).

Air Lift Pumps.*

The air lift pump is gradually forcing its way into use, though it possesses the disadvantage of requiring considerably more power to work it than is required for plain lift pumps. The particular and peculiar advantage of the air-lift pump lies in the fact that it does its work without a single piece of moving machinery being placed below the surface of the earth, and it can be worked at any reasonable distance from a central source of power.

For the sake of those who are not acquainted with this pump, a brief description may be given of the principle on which it works, and this will readily be understood by the aid of the sketch.

Let it be supposed that *W* is the liner of an artesian well in which when no water is being pumped, the rest level of the water is at *RL*. Calculation of the yield shows that when a given quantity of water is being drawn from the well, the water level will stand at *WL*. Then x is the head which yields the given flow. As the flow of water varies with the square root of the head of supply, the out-

* By W. H. Booth, in the *Electrical Review* (Eng.).

put of a well is determined from $\sqrt{x} : \sqrt{y}$, where y is the value of x for some known and actually tested rate of yield. Having found y, we can then fix the value of x very approximately.

A rising main M is inserted down the borehole to a depth d, below the yield level WL. Inside this pipe a small pipe, A, is carried down to the same depth. If the pipe A were filled with oil, the level of the oil would stand above the rest level RL of the water about 20 per cent. of the distance, D, before any oil escaped at the perforations at the base of pipe A. By continuing to pour in oil, it would escape at the perforations, and would rise in drops through the water in the annular space between the two pipes A and M, forming a column of mixed oil and water of a mean specific gravity less than water. Therefore the liquid in this annular space would rise above the level RL, and if it could flow away at that point to which it rises, we could draw water out of the well simply by pouring oil down the pipe A, sufficiently quickly for the oil to form a series of water-separated plugs in the pipe M.

What we have done is simply to produce a liquid column of less specific gravity than water, and the solid water column balances a greater length of the liquid of lighter specific gravity. Using the same apparatus, we pump air down the pipe A. The air forces out the water, and finally escapes at the perforations, compressed to the pressure equivalent to a head of water, D. The air compressor must thus be capable of getting up a pressure in pounds per square inch equal to 0.43 D where D is measured in feet. Escaping into the pipe M, the air forms itself apparently into plug, with plugs of water alternating. As the air rises, it expands as the pressure upon it becomes less, and the plugs lengthen and do work in lifting the water equivalent to the work done in compressing the air, less the heat of compression which is lost. If the outlet of the rising main is at O, we must then have the united length of all the water plugs in the height H of rising main, less than the height d between the foot-piece and the level WL at which the water now stands, for it will fall the distance x during pumping—that is to say, the pressure of the solid column of water d must exceed that of the mixed column H before we can get an outflow at O.

This is said to be obtained in practice when the height d is from 1.5 K to 2 K.

If, for argument, we assume $d = 2$ K, then the length of air-plugs in the length H must be more than the length K. If just of the length K, the outer column d would only just balance the inner column H, and there would be no flow. The weight of the air-plugs may be neglected.

In the pipe M, up which the air and water escape, the air starts from the bottom at the absolute pressure $p = 0.43\,d + 14.7$, and it escapes practically at atmospheric pressure at the discharge point O, its last remnant of pressure being converted into projectile energy of the water which is shot out at some velocity.

As the air has to travel up the iron pipe with the pumped water, it can safely be said that the expansion will be isothermal, the expanding air taking up heat all along its path, and the mean pressure in the length H must, therefore, be $p \times \dfrac{1 + \text{hyp log } r}{r}$, where p is the initial pressure $= 0.43\,d + 14.7$, and r is the number of expansions or the number of atmospheres equivalent to p. Thus $r = 1 + \dfrac{0.43\,d}{14.7}$, or very nearly $1 + \dfrac{d}{34}$.

Thus, if we find a value for $d = 68$ ft., we have $p = (68 \times 0.43) + 14.7 = 44.1$; then $r = \dfrac{29.4}{14.7} + 1 = 3$ atmospheres, and, of course, 3 expansions in escaping.

As the value d will always be given in feet, the mean air pressure in the rising main may be found by a formula based on d, and this we may write—

$$\textbf{Mean pressure} = p \left\{ \frac{1 + \log_e \left(1 + \frac{d}{34}\right)}{1 + \frac{d}{34}} \right\}$$

For the assumed value of $d = 68$ feet this becomes 44.1

$$\left\{ \frac{1 + \log_e 3}{3} \right\} \text{ or } 44.1 \left(\frac{2.1}{3}\right) = \text{nearly 31 lbs. absolute.}$$

Practically, the air will in this case occupy a bulk fully double its normal, and as we have found that it must fill a length = K of the rising main, we must pump in

fully double this air when measured at normal atmospheric pressure.

In other words, if $d = 2$ K the bulk of atmospheric air forced in must be the same as that of the water it will raise. Frictional resistances and the residual or final energy in the escaping water and air all go to reduce the efficiency and render it necessary to force more air than the above calculation shows to be a theoretical minimum.

The difficulties and desirabilities of the system are as follows:—Except in very copious wells the value of x is quite considerable; it may be as much as 50 feet in a London well. In starting to pump, the air pressure must overcome the pressure of a head of water = D, but as soon as flow is established the water level begins to fall until it reaches the supply level, M, and the pressure of air at the compressor of course falls by the equivalent of x, and the power to compress the air is correspondingly reduced. The driving power may sometimes be necessarily much greater than is needed during pumping, and where the yield drop, x, is large the plant outlay is made somewhat excessive.

Though the air expands isothermally, it cannot so readily be compressed on an isothermal, because the exposed surfaces of the compressor bear a much less ratio to the air volume than does the surface exposed in the rising main. Practically, the expansion takes place at 50°, this being a degree or two colder than all artesian water supplies from ordinary depths.

In the adiabatic compression of air the heat in foot-pounds generated in compression from p_0 to p is—

$$\frac{Af_0}{y-1}\left\{\left(\frac{p}{p_0}\right)^{\frac{y-1}{y}} - 1\right\} \text{ where } y = 1.408$$

A = 53.15 t_0, p_0 and p are respectively the absolute atmospheric temperature, the atmospheric pressure and the reservoir pressure.

The heat generated increases the volume of the compressed air, and would be all recovered if the air were made to expand without being cooled down.

In Figure 2, if OV_0 be the curve for compression of air isothermally, OV_1 will represent its adiabatic compression, and its final volume become VV_1 instead of VV_0. The difference represents work wasted and to be economized by cooling the compression cylinder.

By means of compound compression or stage compression with good intermediate cooling, the efficiency of compression is much improved. Thus where $p = 4$ atmospheres, the efficiency of one stage compression and expansion is .669, of two stage .817. At 50 atmospheres the numbers are .322 and .567, with a three stage efficiency of .685, showing considerable advantage in stage compression. Probably

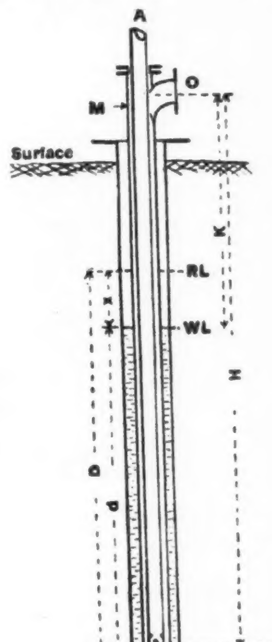


FIG. 1.

the actual curve in Figure 2 will lie between the other curves, because some cooling goes on during compression. The probable curve is shown dotted. At six atmospheres the loss of ideal adiabatic compression is about 25 per cent., and an ideal two-stage compression has about 12 per cent. loss. Both these losses are reduced by cooling, but cannot in ordinary practice be brought down to the line VV_0. In an artesian well, with practically

isothermal expansion, the volume of air which starts at VV_0 will expand along the isothermal V_0 O, simply because it absorbs heat from the water. Did it not absorb heat a volume $= VV_1$, would be necessary, expanding along the curve $V_1 O$. Therefore, in the air-lift pump, though there is the usual loss, due to partially adiabatic compression, some of the work of raising the water is actually obtained from the water itself in the form of heat.

The higher the pressure necessary, or the greater the height K in Figure 1, the greater will be the benefit of stage compression. A second disadvantage of air-lift pumps is the large ratio of $d : K$ that is necessary. This disability is serious when the depth K is great. In London the depth K is often as much as 150 feet. If K is measured from the surface and $d = 2$ K, the height H must be 3 K = 450 feet. A London artesian well only requires to be

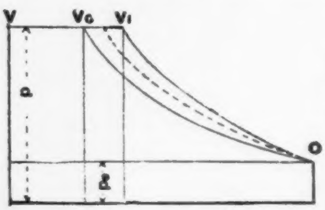


FIG. 2.

FIG. 3.

from 300 to 400 feet in depth, so that with the above conditions the necessary depth for yielding the water supply is less than that for the pump. At the works of the South London Electric Supply Co., which are rather beyond the so-called London basin, the level RL is only about 70 feet below surface, and the additional head, x, necessary to give the yield was only so much as permitted of the pump extending about 320 feet below surface, while, at the same time, K was measured from a point nearly 30 feet above surface. The pump in fact, delivers to the raised tank.

The advantages of the air-lift pump are as follows:—First, there is nothing but plain pipe down the bore-hole. Secondly, the machinery may be any distance away from the bore-hole so long as the air pipe is tightly jointed. Thirdly, the maximum yield of a well can be got out of a smaller and cheaper hole. The yield of a deep well pump is the measure of the capacity of the bore-hole, and a 6,000-gallon pump calls for a 10-inch lined hole, whereas the same yield can be got out of a 6-inch or less hole by the air-lift system.

The arrangement of Figure 1 may be reversed, air being forced down the pipe M and water rising up the pipe A, or the air pipe may be independent and carried down alongside of the rising main with a turned-up nozzle, as in Figure 3.

As in many cases the pipes are carried down past some or all of the water bearing horizons, care should be taken that the outside diameter of the largest pipe is sufficiently less than the diameter of the bore-hole to permit the water to descend and reach the foot piece or the yield may be crippled. By noting the pressure gauge on the air reservoir, there can be found from its maximum reading whether any change in the height D occurs. Similarly the gauge tells when pumping is going on steadily, what is the height d, and consequently the value of $x =$ D $- d$. If x is found to be less than anticipated, an economy of power may be effected by reducing the total depth H which should be a minimum. If the yield of a well is insufficient for the size of pipes employed the working will be spasmodic, and if A has been made the rising main, as it perhaps had better be, its diameter may with advantage be reduced. A rising main too large for the flow of water will fail to act altogether, for the air plugs will break and release the water which will fall back. A certain velocity of flow is necessary to maintain perfect action.

There are within 30 miles of London large areas of watercress beds supplied from artesian wells. The trade is profitable where the well flows freely through the winter, because the water is warm, 51°, and the cress can be grown in winter by its aid. There are many wells which now stand a few inches only below the overflow point. The application of air lifts to these wells would be cheap. An immersion H of very small amount would alone be necessary, and would demand very little power to produce a copious flow of water. This is an industry not hitherto tapped by power distribution, because the importance and magnitude of the industry are unsuspected. As an example, a well is required to yield 10,000 gallons per hour by itself or in company with others. Its natural head is 1 foot down, representing

100,000 foot-pounds of work, and failures to flow are common with only 2 inches or 4 inches of short head. The power is thus $\frac{1}{20}$ horse-power net, or, say ¼ horse-power after liberal allowance.

As £100 may easily be expended on cleaning and replanting a frost-killed bed, it is clear that the subject is of more than trivial importance, especially since the overflowing wells about London have been reduced below flow level by the operations of the water companies, sworn statements of the water companies to the contrary notwithstanding.

Power Required for Air Lift.

The following data may be of interest to readers who have to deal with the air lift, says A. H. Goff, of Roswell, N. M., in the *Engineer*. For the proper working of an air lift a certain amount of submergence is necessary. For the most economical and efficient results a submergence of 60 per cent. should be used. That is, 60 per cent. of the total length of the water discharge pipe should be below the water level in the well when pumped to its full capacity. For instance, let us assume that in a well 200 feet deep when pumping the water sinks to 40 feet below the surface of the ground, and it is desired to lift the water 20 feet above the surface of the ground. This gives a length of pipe 60 feet to the water level in the well, and as this does not include the submerged part of the pipe it is only 40 per cent. of the total length of water discharge pipe, the total length will, therefore, be 60 feet plus 1½ times 60, or 90 feet submergence, making a total length of 150 feet of water discharge pipe.

RATIO OF WATER TO AIR REQUIRED.

For Lifts not Exceeding	
25 feet	2 vols. of air to 1 of water
50 feet	3 vols. of air to 1 of water
75 feet	4½ vols. of air to 1 of water
100 feet	6 vols. of air to 1 of water
125 feet	7½ vols. of air to 1 of water
150 feet	9 vols. of air to 1 of water
175 feet	10 vols. of air to 1 of water
200 feet	12 vols. of air to 1 of water

VOLUME OF FREE AIR, AIR PRESSURE, SUBMERGENCE AND HORSEPOWER.

Lift, Ft.	Submergence, Ft.	Air Pressure.	Free Air Per Min. Cu. Ft. Per Gal.	I. HP. Per Gal.
25	38	17	0.3	0.0184
50	75	33	0.4	0.0426
75	113	49	0.6	0.0828
100	150	65	0.8	0.1320
125	188	82	1.0	0.1910
150	225	98	1.2	0.2544
175	263	115	1.4	0.3150
200	300	130	1.6	0.3808

It is not safe, unless under very favorable conditions, to figure on raising the water by the air lift system more than 200 feet above the lowest water level in the well. Nor is it always safe to extend the horizontal discharge more than 500 feet, as the air lift is not adapted to pumping horizontally to any great distance, unless reinforced by a pneumatic direct pressure pump, or an ordinary piston pump, either of which, however, could be operated by compressed air from the same pipe that supplies the well.

Suppose, for instance, that it is desired to lift 120 gallons of water 100 feet high per minute. It will be seen by the above table that this will require 150 feet submergence, thus making 250 feet of water discharge pipe, 65 pounds air pressure, 96 cubic feet of free air per minute and a compressor developing 15.84 horse-power.

New Drill Sharpener.

Machine drill sharpening on the Rand has, by reason of the large number of jumpers used daily, assumed a weighty aspect in the economics of the mines. A machine that will effect a saving of 45 per cent. in labor and 25 per cent. in fuel represents a valuable addition to the blacksmith's shop. On Thursday last an inspection of such a device was afforded in the shape of the machine manufactured by Ryder Bros., of Bolton, England, under Lightbody's patents, at the Langlaagte Deep Gold Mining Company. A contract has now been entered into with the Rand Mines, Ltd., after a seven weeks' trial. Another machine is being placed in the same shop (one of 70-drill capacity). Further orders have also recently arrived from Western Australia, and a continuance of these favors is justifiably anticipated if the efficiency noted is maintained. An idea of the speed that can be attained

is evident from the following results of the two last tests:

Drills Sharpened.	Time.	Average No. of drills per minute.
820	5 hrs. 52 min.	2.3
620	4 " 9 "	2.5

A good drill sharpener with boys by the old manual methods may get through 200 drills per diem, whereas this machine can sharpen 1,400 in a ten-hours' shift. In each of the above trials the sharpener was held up for bits waiting on the fires.

Two large forges are necessary to keep the machine going, and two white men and four natives. Instead of being squeezed the drills are hammered, and loss of steel through trimmings is minimized.

This Lightbody machine performs its own shanking and forging throughout from octagon steel, and it is not necessary to have the star steel ends which are usually welded on to the bar. The ability to form the cutting edge out of octagon steel does away with the necessity for welding.

The machine is compact in form and performs four distinct operations. First may be noted the "fullering." This part of the machine consists of a series of rotary "fullers" revolving at a speed of 4,000 feet per minute, and delivering about 1,900 blows per minute. The action of the "fullers" is to draw out the centre of the bit and to place the steel well out on the worn corner. In short, the object is the same as that effected in what is known as "peening" when drills are being sharpened by hand. After the bit has been well sharpened in these "fullers" the operator takes it to the dolley.

The second phase of the process reveals a particularly ingenious mechanical device. There is a movable anchorage adjustable to all lengths of drill, and the drill is firmly held up to the dolley or shaping die. At the other side of the die is a hammer with a horizontal travel. This hammer is brought into operation automatically as soon as the drill is in position; it moves by means of a crank shaft action, and the belt is thrown on to the fixed pulley by means of an arm working in conjunction with the dolley block. The hammer head works very rapidly.

The third process is known as swageing. After dolleying the drill is taken to the swageing frame, which keeps the cruciform section of steel correct when old drills are being sharpened, and in the case of new drills being made from octagon steel, hammers up the cutting end into star shape. In this frame are four sledging dies actuated by plates on the inner periphery of a conical wheel. Here something like 510 blows per minute are delivered. The wheel is so constructed and connected with the anchorage that a correct section is automatically provided for.

After the sledging process the drill is placed in the sizing frame, which brings the "wings" of the drill bit to the correct size. These sledges are connected with the anchorage so as to automatically adjust the size of the drill according to its length. This arrangement insures that every drill will "follow" when it is put to do its allotted work in stope or drive. The drill is now practically finished; it is merely subjected to a final dolleying and then placed in the tempering bath.

The Lightbody machine has been working for seven weeks at the Langlaagte Deep, and working half time it has sharpened all the drills for thirty rock drills. The shape of the drill bit as turned out by the Lightbody machine is a special feature, approximating, though in exaggerated form, to a Maltese cross. That is to say, the wings are narrower near the centre of the drill than at the cutting edge. This is the reverse of the usual style. Bits made in this way are said to cut more rapidly on account of the easier clearing of the powdered rock. It is also worth noticing that the number of drill bits required for these thirty machines has been reduced by 150 in seven weeks. Better hammering, and the fact that the steel has not to be heated to so high a temperature, are the main cause of this.—*South African Mines.*

A Test of an Air-Lift Pumping Plant.

The Ingersoll-Sergeant Drill Company reports the following results secured in a test made recently on a Pohlé air-lift pumping system installed in a large Southern brewery. The compressor furnishing air was an Ingersoll-Sergeant Class "E"

machine, size 10 inches by 10 inches, and it was run at a speed of 100 revolutions per minute, corresponding to a piston displacement of 89 cubic feet of free air per minute. In this test the air and water pipes were lowered to a depth of 167 feet below the surface for the purpose of cleaning out an accumulation of about 33 feet of sand and dirt which had gathered at the bottom of the casing. This necessitated the very deep submergence and accounts for the unusual air pressure required at the compressor. After the well has been cleaned out thoroughly the pipes will be raised until a depth of about 98 feet is reached, when an air pressure of 40 or 45 pounds will deliver the required quantity of water. The details of the test are as follows:

Original depth of the well....	223 feet
Depth of the well when the test was made.............	183 feet
Diameter of the well casing...	7½ inches
Standing water level.........	14 feet
Drop in level when pumping..	21 feet
Lift above the surface........	8½ feet
Total lift from lowest water level, when pumping, to the point of discharge..........	44 feet
Depth through which water and air pipes were lowered	167 feet
Submergence	74 per cent.
Quantity of water lifted (per minute)	264 gallons
Air pressure at starting......	68 pounds
Working air pressure.........	60 pounds
Diameter of water discharge pipe	3½ inches
Diameter of air pipe.........	1½ inches
Horizontal distance from receiver to well.............	246 feet

Notes.

The New York Air Brake Co. has received a contract to supply the air brakes for the Rock Island system for a period of several years.

The Rand Drill Co. is issuing a quarterly known as *Air Power*. The first number appeared in January. It contained descriptions of Rand machinery and other information of interest.

United States Senator Foraker has offered an amendment to the Post-office appropriation bill adding $100,000 for pneumatic tube service in Cincinnati, Cleveland and other cities of that class.

Among the recently incorporated companies is the Elevator Air Brake Co., of Chatham, N. Y., with a capital stock of $250,000. The directors are LeRoy Clark, A. H. Meech, I. H. Lehman, New York City.

The Pneumatic Tube Co., of Missouri, is attempting to secure a franchise in St. Louis to construct and maintain a system of pneumatic tubes under the streets for carrying and distributing messages and packages.

A leaflet, entitled "Baby Compressors for Air or Gas," has just been issued by the Rix Compressed Air and Drill Co., of San Francisco, Cal. It describes briefly some of the different types of Rix compressors and varied duties for which they can be used.

Kerbaugh & Co., railway contractors, have established a compressed air plant in an old factory building at Safe Harbor, Pa. The plant will supply air for running drills and other tools needed in contract excavation work for the Pennsylvania Railroad.

The Philadelphia Pneumatic Tool Co., of Pennsylvania, has been incorporated at Camden, N. J., with a capital of $1,000,000, to take over the business of the Philadelphia Pneumatic Tool Co. The incorporators are Julius Keller, C. F. Binkley, C. S. Bell and M. D. Aber.

The issue of the *Engineering Record* for January 28 contains a description of the new St. Louis terminal station, under the title " The Power Plant of a Modern Railway Terminal. It is written by Mr. J. R. Bibbins. Brief reference is made to the important part which compressed air plays.

In a description of one of the terminal stations of the Midland Railway Company, in England, mention is made of the Westinghouse gas engine, which are used to drive the electric generator. A motor-driven air compressor in duplicate furnishes compressed air for starting the engines.

The Alaska Fuel, Power and Transportation Co. has been incorporated at Camden, N. J., with a capital of $1,000,000. Its object is to manufacture and deal in air compressors and electrical machinery. The incorporators were Wm. H. Duval, Warren Dickson and Arch. C. Shenstone.

Postmaster General Wynne has sent to the Congressional Committee on Postoffices a letter recommending legislation providing that the aggregate annual expenditures involved in contracts for pneumatic tube mail service entered into by the Post-office Department shall not exceed $1,500,000 instead of $800 000 as at present.

Articles of incorporation have been secured by the Alton Pneumatic Tool Co., of Fostoria, O., with a capital stock of $100,000. The incorporators were M. M. Carr, E. W. Allen, M. A. Thomas, Fred. C. Wein and J. D. Hare. It is reported that the manufacture of the tool will be started in sixty days in the building occupied by the Atlas Safe Co.

Another tunnel to connect Switzerland with Italy is being projected, the intention being to connect the eastern part of Switzerland with the south. A conference has recently been held in Berne, at which seven cantons were represented, the result being the appointment of a committee on the piercing of the East Alps. The eastern Swiss cantons, Vorarlberg and southeastern Germany, are, of course, specially interested.—*Citizen* (Eng.).

The Rand Drill Company has just issued two compressor catalogues, Nos. 10 and 11. The No. 10 catalogue describes fully the "Imperial," Type 10, steam, belt, gear and silent chain driven air compressors, giving speeds, capacities, air pressures, horse-powers, etc., and is illustrated throughout with half tone cuts of the various styles of Type 10 machines. Catalogue No. 11 illustrates and describes the "Imperial" Type 11 machines, which are vertical compressors built for driving by belt, gear and silent chain.

The Vacuum Cleaner Co., with offices at North Plainfield, N. J., has been incorporated under New Jersey laws. The capital stock is fixed at $1,060,000. The incorporators were D. T. Kenney and Wm. G. Besler, Plainfield, N. J., and Harry B. Hollins, R. W. DeForest, Thos. Ewing, Jr., and W. K. Vanderbilt, Jr., of New York. The company is to manufacture, operate and deal in vacuum and other cleaning apparatus. This company is installing a cleaning plant at the Jersey City yards of the Central Railroad of New Jersey.

The A. S. Cameron Steam Pump Works, foot of East Twenty-third street, New York City, report the sale of three more of their horizontal piston pumps to the O'Rourke Construction and Engineering Company, of New York City, contractors, for the improvement in the Pennsylvania Railroad tunnel, delivery being made to the Manhattan side. The O'Rourke Company also has quite a number of Cameron pumps in use on the Weehawken side of the Pennsylvania tunnel, and also along the line of the improvement in the New York Central Railroad tunnel, in New York City.

Rand Drill Company has just issued the fourth edition of its catalogue "C," for air and gas compressors. This catalogue lists and describes many sizes of the various types of steam (Corliss, Meyer and plain) belt, gear and chain driven compressors, including articles on water impulse and sectional machines, and includes many half tone cuts showing the construction of the Rand standard and special compressors. The volume also contains articles of a semi-technical character which deal with the phenomena attending the compression and expansion of air; also a number of tables of value to those interested in the study of air compression.

Small auxiliary hoists may be operated at underground stations for sinking winzes, shafts, etc., and may be driven by electricity, steam or compressed air. Steam is objectionable, as it heats the mine workings, and the exhaust has a deteriorating effect on the timbers. There is also a great loss by condensation. As at most mines there is a compressed air plant, air would probably be the most satisfactory, as involving little additional expense. A small hoist that's been used on the surface for prospecting would be suitable for underground use. If it is to be frequently shifted a smaller hoist is preferable to a

larger one. Shifts are frequently sunk below the lowest working level by means of auxiliary engines, a bulkhead being placed over a portion of the shaft for safety of men below.—Lake City (Col.) *Times.*

Two English patents have been obtained by W. C. Johnson and G. C. Pearson, both of Victoria Works, Old Charlton, Kent, for improvements to rock drills. One consists of a mechanism for converting rotary into reciprocating motion to operate the drill. The other covers a percussive rock drill in which the chuck or spindle is drawn back by cams on a revolving shaft or by lugs on an endless chain. The forward stroke is effected by air compressed in the rear end of the cylinder by the piston. The front and rear ends of the cylinder are connected by a bye-pass and non-return valve, which is placed to allow cushioning on the forward stroke, and also to allow air to pass to the rear end of the cylinder to make up for leakage therefrom, fresh air being admitted to the forward end through a port. The piston may be fixed on the tool spindle or chuck or on a loose sleeve placed between springs.

S. E. Alley, of Glasgow, Scotland, has received the English patents for a multistage air or gas compressor. It combines a differential trunk reciprocating piston, a cylinder divided by it into two compression chambers, an inlet conduit and an exhaust conduit appropriated to and terminating in each of the two compression chambers, sliding valves adapted to open and close both conduits of each compression chamber, a valve-operating mechanism by which the sliding valves are given simple harmonic motion across the conduits, two fluid-operated valves each controlling one of the exhaust conduits, and situated at a point therein, which is farther from the cylinder than are the sliding valves, a loading spring applied to each of the fluid-operated valves tending to keep each valve always in a position in which it closes the conduit, and so proportioned as to apply to the valve a thrust greater than that which, immediately that the sliding valves open the exhaust conduit is exerted upon it in such a direction as to tend to open it by the air in compression in that portion of the exhaust conduit which is between the loaded fluid-operated valve and the piston.

A unique feat of bridge repairing recently performed on the Illinois Central Railroad shows the high state of efficiency that compressed air machinery has attained, and the important new fields that it is invading. By the aid of a portable gasoline air compressor, field riveting was done on a railroad bridge without in any way hindering traffic over the structure. The compressor was set outside the rail a sufficient distance to permit the passing of trains. An entirely new floor system was riveted in position in this particular bridge without interfering with the passage of trains. The compressor occupied a central position on the bridge and air lines were led in either direction from the receiver tank.

Since this performance, similar arrangements have been put in operation on the Illinois Central, on both new and repair work. The machines are generally placed in care of the superintendent, and after they are started little or no attention is necessary, except the filling of the oil cups. The arrangement of the compressor is automatic and is under the control of the engine's governor, thus making it economical, both in the use of fuel and in effecting a great saving in attendance.—*The Technical World.*

The latest news from the Simplon Tunnel tells us that the engineers have circumvented the bad place in the centre of the tunnel, which has so long withstood their efforts. By means of parallel and cross tunnels the difficult spot has been isolated, and only a thickness of 29 metres separates the advancing tunnels from either side. The general plan of the tunnel has been so arranged that the gradient rises from both ends, the highest point, therefore, being in the centre of the working. The object of this arrangement has been to provide efficient drainage from the face of the rock being perforated, and the precaution has proved of the utmost value during the long-continued operations. Its most beneficial effect will, however, be perceived now, since the slope will permit the water from the hot spring that was encountered on the Swiss side to escape in both directions, and allow of an early resumption of the work, which

will soon lead to the complete perforation of Mont Leone. The gigantic labor of constructing a tunnel more than twelve miles long, and in which for a considerable time the workmen have been practically one and a half miles below the surface, 50 per cent. more than has ever been attempted before, will not only solve many important questions in engineering, but also not less important problems connected with the health of the miners and their capacity for continuing work under such circumstances. With the increased depth to which coal mines are carried, both in this country and in Belgium, such matters become of the first importance, and it is fortunate that very careful statistics have been prepared by the management.—Liverpool (Eng.) *Post and Mercury.*

Fire in a tunnel during its construction is rather unusual, and for this reason it may be of interest to mention a recent incident in the heading of the north tube of the tunnel being driven under the East River between the lower end of Manhattan and Brooklyn. During the night of January 29 a fire was started in this tube at a point about 1,500 feet from the Battery Park shaft and about 65 feet below the high-water level, where the air pressure is about 23 pounds. There are two air locks in this tube, the second being about 500 feet from the heading. As soon as fire was discovered water was forced into the heading through a 6-inch pipe to flood it, care being taken to maintain full air pressure so as to prevent any danger of collapse. The heading was filled in about 48 hours and the fire extinguished in this way, after which the water was pumped out again. The fire was confined entirely to the blocking above the timber sets, and as it did not injure the roof arches no material damage was done beyond the interruption of the work. The chief engineer made an inspection as soon as the water was pumped down enough, and found the tunnel in good condition. The origin of the fire is supposed to have been a workman's candle carelessly left lighted among the blocking. The timbering is massive and would not ordinarily take fire readily from a small flame, but combustion is so greatly accelerated under the heavy pneumatic pressure that a candle flame, when extinguished, immediately relights itself. There is 20 feet or more of earth and rock between the north and south tubes, and the smoke penetrated this material so as to be perceptible for the south heading.—*Engineering Record.*

Glass bathtubs are the recent production of a German inventor, who has succeeded in making them commercially possible. These new tubs are much inferior in appearance to the porcelain tubs so generally used, and in utility are nothing better, save in hospitals where medicated baths are oft-times given patients. The method of blowing them, however, is both unique and interesting.

A thick cast-iron plate having an opening the exact shape the glass tub is to be, having a removable frame resting on its margin and held in position by locking levers, is mounted on a hollow shaft which is journaled in bearings and arranged to rotate. The removable frame holds the outer edge of the glass within the cast-iron plate. Compressed air is used for blowing such a large piece and is forced into the molten glass by means of the hollow shaft and the perforated cast-iron plate. A bedplate supports the apparatus.

Sufficient molten glass is poured upon the iron plate from a ladle carried by a traveling crane. The glass spreads over the plate and under the frame, and rapidly cools at its outer edge. At this point plate, frame and glass are turned through a half circle, so that the top frame is then underneath and the layer of hot, smooth glass hangs from the plate, supported by its chilled outer edge. The central part sinks uniformly, the bedplate being brought into contact to secure this result, and the bottom of the tub is formed. The bedplate, falling slightly, pulls the glass down and so forms the walls, and then, through the shaft and cast-iron plate, compressed air is skillfully introduced into the tub, so as to give the walls whatever inclination desired. This done, the blast is turned off, the locking levers release the movable frame, and the tub, still hot, is rushed to the annealing oven, where it is carefully annealed, this operation being the most important of all.—*Popular Mechanics.*

The vast number of applications of compressed air to modern engineering problems have proved it to be one of the most flexible and efficient agents for the

transmission of power over comparatively short distances; and when its advantages come to be more generally appreciated, its use will be extended to many of the operations of everyday life. In view of its rapidly growing field of usefulness, the description of various forms of air compressors, which will be found elsewhere in these pages, is of timely interest. Owing to the wide variations of air pressure required for different services, which range from a few ounces to several hundred pounds pressure per square inch, a number of different types of compressors have been developed. With the fan and blower types, whose limits of economical operation are within 1 pound pressure, few difficulties are found in the construction of the compressing machinery, which is extremely simple.

As the pressures increase, however, the machines become more and more complicated, owing not only to the greater power required, but also to the heating of the air during compression. The dissipation of heat is, in fact, one of the most difficult problems with which the designer of air compressors has to contend. The use of water jackets for cooling the air in the compression cylinders is general, but this does not effect thorough cooling, as only a small portion of the air in the cylinder comes in contact with the jacketed parts. This difficulty has led to the use of compound machines, in which case inter-coolers are generally used between the different stages of compression, which cause the air to shrink in volume between the stages. A properly designed inter-cooler should reduce the air in the cylinders to the temperature of the outside air. The economy of compressing in several stages—or, in other words, compound compressors—is shown from the fact that in compressing air up to 100 pounds the heat loss reaches about 30 per cent. By compressing in two stages this loss is cut down to less than half; and in four stages it is reduced to 4 or 5 per cent. It is evident, therefore, that the higher the pressure required the more essential is the use of compound machines. It is probable that much of the delay in the adoption of compressed air for numerous purposes has been caused by the complicated and ponderous machinery formerly used; but this objection is rapidly disappearing with the introduction of simple, durable machinery, which can be readily operated by entirely unskilled attendants.—*The Technical World.*

At a meeting of the Institution of Mining and Metallurgy, held on the 15th of December, at the rooms of the Geological Society in Burlington House, a paper was presented by Messrs. R. Arthur Thomas and W. P. O. Macqueen on "The Dust in the Air and the Gases from Explosives in a Cornish Mine (Dolcoath), and the Efficacy of Methods of Dealing with Them." The authors' investigation was undertaken in view of the evidence that miners' phthisis is due to the inhalation of stone-dust in suspension, with the object of throwing light on the following points: (1) The amount of stone-dust present in the air during different operations at the Dolcoath mine; (2) the efficacy of water jets and other means now in use in that mine for preventing the formation of dust; and (3) the amount of the chief gaseous impurities present in the air after the use of the ordinary gelatine dynamite employed for blasting in Cornish mines. The result of their inquiries were set forth in an elaborate series of tables. In drilling dry holes with machine drills it was found that, whatever was the position of the hole, more dust was almost always produced at the start and for the first few inches than when the hole was being drilled deeper; and that most dust was produced when the rock was dry. The results, obtained during the ordinary course of working, of drilling downward holes with machine drills, water being thrown in from a can, showed how ineffectual was this system unless great care was taken and a copious supply of water continuously thrown on from the start and before the hole was deep enough to hold water. The use of a water jet with machine drills entirely prevented the formation of dust, provided the jet was used from the start and was properly directed; but when the holes were deeper than 2 feet or 2½ feet it became extremely difficult to direct the jet to the bottom, and frequently a ring would be formed which, when broken and the drill extracted, would allow the accumulated dust to escape. A coarse spray, sufficient to keep the surface of the rock constantly wet, especially at the start, was perfectly efficient in stopping dust. Such a spray consumed less water than a jet and had obvious advantages. As to hand-

drilling, there was found to be a certain amount of dust produced, especially at the start; but still the amount in suspension and liable to be inhaled was inconsiderable in comparison with that produced by rock drills, which bored a much greater distance in a given time. In shoveling, filling and rock-breaking, unless means were taken to damp the broken ore or granite, a considerable amount of dust was present. When, however, the ore had been previously damped by the use of James' water-blast no dust was found. That device was also very effective for settling the dust after blasting in ends and risings. By far the greater part of the dust was drowned down at once, and the air in the end or rise was practically clear of dust within a few minutes. A certain amount of smoke might be left in the air, but this appeared to be usually washed fairly free from stone-dust. The blast of water and air thrown in by means of James' apparatus had a striking effect on the amount of carbon monoxide present, reducing it to from a third to a fifth of what it was before.—*Colliery Guardian* (Eng.).

Electricians are to-day so confirmed in the habit of victory that they are disposed to wrath when they confront a label, "No Admittance." Yet such is their fortune when they come to a quarry or a mine, for there they find compressed air in possession, with small prospect of being dislodged. Picks, hammers, drills and hoists driven by compressed air may be wasteful enough of the energy they employ, but what of that in comparison with their ability to stay in order despite the hardest work and the roughest usage? An electric tool, with its delicate winding of silk-covered wire, soon comes to grief in the severe percussion of drilling ore and rock. And an incidental gain in using compressed air in deep shafts of iron ore, or coal, is that the machinery gives out pure air, in some degree aiding ventilation. The beginning of all this began where one would hardly have looked for it, namely, in a dentist's chair. An artist in teeth, with the proverbial ingenuity of his race, a good many years ago devised a tiny air hammer with which he forced gold leaf into the cavities of molars. To-day the lineal descendant of that device is not only pounding away at veins of ore, it is decorating marble and granite at the rate of ten thousand blows a minute.

Fill to the brim a tumbler with water, then take a straw and dip it to the bottom of the glass, blowing as heartily as you can. At once the water overflows. Deepen the container, use at its base compressed air instead of breath, and you have the Pohle pump which lifts water into reservoirs for the supply of towns; or which, in chemical works, raises liquids so corrosive that no other lifter is feasible. Pumps of the same kind bring oil from wells to the surface of the ground, raise sewage and give it distribution over the earth, and have been adapted to moving the water ballast of ships from one compartment to another, so as to give the vessel just the trim or inclination desired.

With air compressed to the moderate pressure of the breath, we may blow dust from a sheet of paper, or crumbs from a plate. All that we have to do to take the dust and dirt out of carpets and upholstered furniture is to employ air under higher pressure. With an air nozzle in his hands, its tube connected to an air compressor, a Pullman porter cleanses his car with astonishing speed and thoroughness. His blast finds its way into corners where a damp cloth would have to remain outside. By means of large air-tight hoods this method cleanses carpets with out their removal from floors. All, of course, with much promotion of health; the further physicians go with their microscopes the more they are convinced that dust and dirt are among the most formidable carriers of disease.

A lady's toilet table usually displays an atomizer. Its little bulb of rubber, when sharply compressed, sends forth a tiny stream of perfume, or it may be some medicament for a cold or a cough. This simple apparatus much magnified becomes a painting machine. Nowadays when a railway company builds a thousand freight cars, or rears a succession of steel bridges to replace structures of wood, the paint is applied not by hand, but by an air-nozzle united with a tank of compressed air. In other departments of railroading the same agent is much in evidence. It operates the brakes; it effectively tamps the track; and in common with other practice of the machine shop, it drills and rivets with the utmost adaptability and economy. In the foundry it works molding machines at half the cost of old-time methods. A blast of compressed air, laden with sand, has manifold uses.

It surfaces castings and removes rust with amazing speed. It engraves glass, sculptures stone, cleans ships, steel culverts and bridges, and gives a new face to masonry that has grown dingy and grimy. In Canada we are familiar with the barbers' clippers which remove hair, none too gently at times. In far Australia shears of like pattern, only bigger, are driven by compressed air to remove fleeces from sheep more quickly and fully than is otherwise possible. Indeed, so varied are the uses of compressed air, so important the field it occupies all by itself, that more than one engineer of note has said: "If the compressed air people put as much brains into their work as do the electricians, electricity would soon have a rival worthy of its steel."—Winnipeg (Man.) *Free Press.*

In the good old days when folks, technical and otherwise, wished to see the latest discoveries in the realm of science, they repair to polytechnics and such like institutions, but now in the new and better days they patronize the vaudevilles for the same purpose. That wonderful compound, liquid air, is to the average layman, and it may also truthfully be said of many of those who have been admitted into the inner circles of science, an unknown quantity, and the extraordinary things of which it is capable are calculated to mystify the mind and delight the soul of every beholder, however great or little his knowledge of low temperatures may be.

By its agency Josef Yarrick, a young man suave in manner and skilled in the arts of entertaining, is enabled to perform many apparently miraculous feats nightly with what he is pleased to term the "magic kettle," and no genii ever had a more obedient vassal. This gentleman prefaces his demonstration by maintaining that there are no chemicals used and that, on the other hand, there is no illusion.

It is very easy on personal investigation to support these statements, for, though it must be admitted that in some of the experiments a chemical action takes place, yet with this the performer has nothing to do, for in all the processes involved it is only required by him to have the initial quantity of liquid air, and an abundant supply of what, in the language of the lamented magical Herrmann, used to be called "talkee-talkee."

The demonstration throughout is, of course, a reality, and yet it is more remarkable in every way than the greatest of Kellar's feats of prestidigitation, and in this it marks the passing of the old line of magicians, who, through sleights, sleeve and trap work, were easily enabled to deceive, not only the most ignorant galoot but the brighest savant; at last all this is changed, for the erstwhile necromancer with his extraordinary skill and superficial knowledge is beaten at his own game, for liquid air will discount ten to one the most brilliant magical soirée the greatest of these has ever produced.

Liquid air, until one becomes familiar with the laws that govern it, apparently contradicts the recognized conceptions of what is and is not possible, and in this lies the whole secret of the fascinating demonstration.

The rising of the theatre curtain reveals a stove whereon a big kettle is steaming furiously; lifting the copper vessel the performer pours out what appears to be water, yet strangely enough it does not wet anything; next he lights a cigar or cigarette at the spout, and the succeeding instant pours some of the liquid on a bunch of grapes, when each becomes as hard as a pebble. Lighting a spirit-lamp under a chafing dish he puts milk, sugar and vanilla into the latter and then pours some of the contents of the kettle on the mixture; imagine the surprise of the audience when, instead of a steaming hot pudding, the result is a steaming cold ice-cream, easily made in a few seconds, and which is immediately served to the spectators; similarly, eggs thus treated are beautifully poached into little cakes of ice frozen so hard that they can be pulverized with a hammer.

When the succulent beefsteak is immersed in the magical liquid it takes on the appearance of oxidized iron, and when struck with a hammer it rings with a pure metallic tone. Even mercury is frozen solid, and, made into the shape of a hammer and nails may be driven into a board with it. Under the action of the intense cold of liquid air tin becomes as brittle as glass, and the artist does not hesitate to force his hand through the bottom of a vessel thus

treated, as is shown in one of the pictures.

That metals will not burn in air everyone knows full well, but a watch may be readily made to take fire when ignited in the presence of the oxygen given off by the evaporation of the liquid air, and soon melts under the intense heat evolved. Another striking experiment is making a candle by freezing kerosene oil until it becomes a solid. Not the least curious of the phenomena presented is the boiling of the kettle when placed on a cake of ice, but when it is remembered that ice is over 300 degrees hotter than the liquid air, the mystery is quickly solved.

One of the prettiest tests is the dissection of a rose, which has been previously crystallized by immersion in liquid air, and when this is done the petals can be broken off like films made of delicate glass. Having exhausted, not the experiments, which are practically unlimited, but the liquefied substance in the kettle which makes them possible, the performer pours the last few remaining drops into a glass and, to all intents and purposes, drinks it, but in this there is a little deception, for the liquid air quickly evaporates, the glass is shown empty and thus the act ends.

One of the peculiarities of the entertainment is that the term "liquid air" is never mentioned, consequently those who are totally in the dark concerning the nature of the fluid are filled with wonder as to what it can be, and how such strangely unfamiliar things as these are done, while those who walk somewhat in the light have only to think a little until they reach a point, and very quickly, too, where their deductions must cease, and thus the difference between the untaught and the learned is only in degree and not in kind.—A. FREDERICK COLLINS in *The American Inventor.*

INDEX.

U. S. PATENTS GRANTED JAN., 1905.

Specially prepared for COMPRESSED AIR.

778,896. PNEUMATIC MASSAGE APPARATUS. Irvin Rhodes, Kalamazoo, Mich., assignor to Oliver A. La Crone, Kalamazoo, Mich. Filed Nov. 20, 1903. Serial No. 181,946.

778,983. PNEUMATIC COTTON-HANDLING APPARATUS. Robert B. Lumpkin, Mart, Tex. Filed June 3, 1904. Serial No. 211,057.

A device for handling cotton, the combination of a fan, a compressing-chamber receiving the discharge from said fan, a suction-pipe connected with the intake of said fan, a gin, and means for conveying a current of air from the compressing-chamber to said gin.

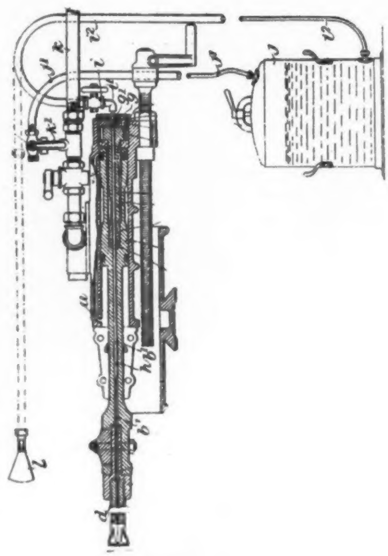
779,070. PNEUMATIC-TIRE CLAMP. Hosea W. Cagle, Marion, Ill. Filed Feb. 5, 1904. Serial No. 192,205.

779,163. PNEUMATIC SPRING. Herbert E. Irwin, Galesburg, Ill. Filed Sept. 30, 1903. Serial No. 175,103.

779,170. DUPLEX FEED-VALVE. Harry R. Mason, Chicago, Ill., assignor to The Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Jan. 21, 1902. Serial No. 90,652.

779,444. PNEUMATIC TIRE. Benton C. Rowell, Chicago, Ill. Filed Mar. 15, 1904. Serial No. 198,196.

779,017. ROCK OR LIKE DRILL. William Wilson, Cleator Moor, England. Filed May 25, 1903. Serial No. 158,722.

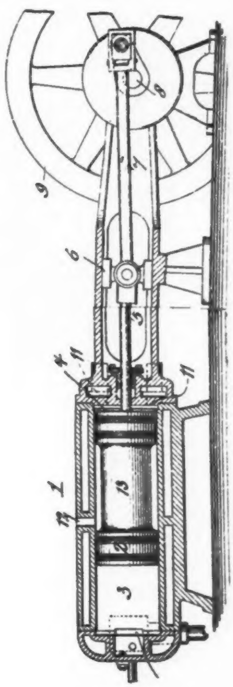


A rock-drill the combination of a cylinder having an axial way through the back thereof a hollow piston working within the cylinder, a hollow rifle-bar working within the hollow of the piston and formed of shorter length than said hollow, a hollow piston-rod fixed with the piston, a hollow chuck removably fixed with the piston-rod and adapted to receive a hollow bit, a pipe connected with a water-supply exteriorly of the cylinder and passing through and fixed with the cylinder end and loosely passing through the bore of the rifle-bar and entering the bore of the piston-rod and a stuffing box beyond the end of the rifle-bar within the hollow of the piston for forming a fluid-tight joint between the pipe and the piston and piston-rod substantially as herein shown and described and for the purpose stated.

779,414. APPARATUS FOR COOLING AIR. Samuel C. Davidson, Belfast, Ireland. Filed Apr. 28, 1904. Serial No. 205,435.

In apparatus for cooling air, the combination with a drum the circumference of which consists of wetted foraminous material, of a fan mounted within said drum rotating independently of said drum and forcing air through the wetted foraminous material thereon.

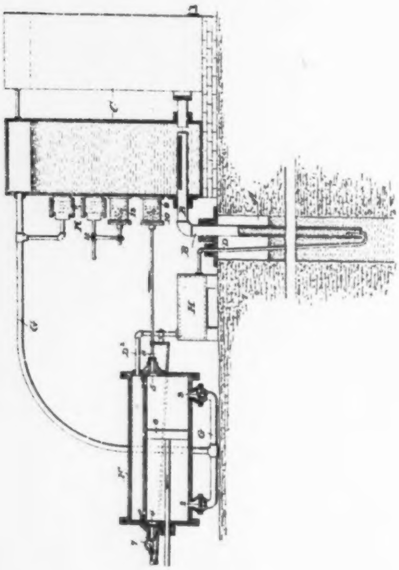
779,385. COMPRESSOR. Warren P. Valentine, Westfield, N. J. Filed Dec. 8, 1903. Serial No. 184,249.



An air-compressor, the combination of a cylinder having the same diameter at both ends and a reciprocating piston fitted thereto, one end of the cylinder constituting a working chamber and having means for controlling admission and exhaust of motive fluid thereto and therefrom, the other end of said cylinder constituting a compression-chamber, and having means controllnig admission and discharge thereto and therefrom, said cylinder and piston having between them a supplemental exhaust-chamber, said exhaust chamber located intermediate said working and compression chambers, and said cylinder provided with a supplemental exhaust-passage communicating with said exhaust-chamber.

779,638. CARRIER FOR PNEUMATIC-DESPATCH APPARATUS. Charles H. Burton, Boston, Mass., assignor to American Pneumatic Service Company, Dover, Del., a Corporation of Delaware. Filed Apr. 23, 1904. Serial No: 204,616.

779,456. LIQUID-RAISING PROCESS. George R. Young, Ridgewood, N. J., and Clifford Shaw, New York, N. Y., assignors to the Bacon Air Lift Company, a Corporation of New Jersey. Filed Feb. 1, 1899. Serial No. 704,104.



The process of raising liquid, which consists in introducing a lighter fluid into a column of the liquid and causing the liquid to rise with the lighter fluid, upon its way to the point of discharge, subsequently separating the lighter fluid from the liquid at greater than atmospheric pressure and while the liquid is on its said way to the point of discharge, discharging the separated liquid at substantially said pressure, and again forcing the lighter fluid down and into the column of liquid, and maintaining the continuous circulation or cycle of the said fluid.

The process of raising liquid to a given height and discharging it therefrom under pressure, which consists in introducing a lighter fluid under pressure from a suitable source into a column of the liquid, thereby lightening the column and causing hydrostatic pressure to raise it, in receiving and separating the liquid and fluid while still confined under pressure, in discharging the separated liquid under the last-said pressure to its point of delivery and in discharging the said fluid under the last-said pressure and again subjecting it to the greater pressure required to again introduce it into the said column, and continuing such circulation of the lighter fluid in a continuous cycle, substantially as set forth.

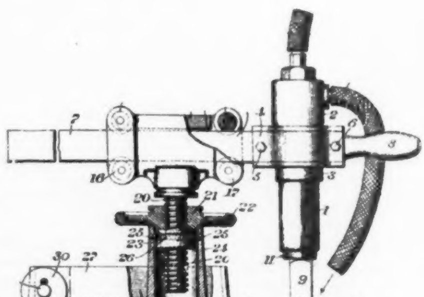
779,598. AUTOMATIC RETAINING AND RECHARGING VALVE FOR AIR-BRAKES. Claude B. Harrington, McMechen, W. Va., assignor of one-half to Harry A. Uhler, O. L. Simms and William J. Duffy, McMechen, W. Va. Filed Mar. 7, 1904. Serial No. 196,810.

779,702. PNEUMATIC TIRE FOR VEHICLES. Samuel W. Fuller, Malden, Mass. Filed June 1, 1903. Serial No. 159,583.

779,716. PNEUMATIC ACTION FOR MUSICAL INSTRUMENTS. Eugene de Kleist, North Tonawanda, N. Y. Filed Mar. 23, 1904. Serial No. 199,528.

779,772. AUTOMATIC DRAINAGE-VALVE FOR AIR AND WATER. William T. Donnelly, New York, N. Y. Filed Oct. 8, 1904. Serial No. 227,744.

779,787. PNEUMATIC TOOL. Herman G. Kotten, New York, N. Y. Filed Mar. 25, 1904. Serial No. 200,063.

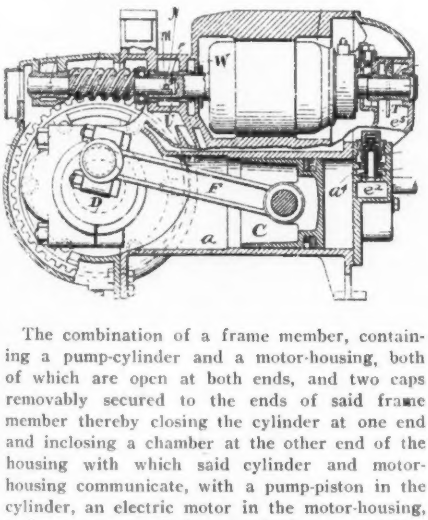


The combination of a pneumatic tool, a bed adapted to rest upon the stone to be dressed and means intermediate of said bed and tool for sustaining the latter, said means comprising an arm attached to said tool, and devices located between said bed and arm and below the latter for vertically adjusting said arm and tool, the latter being capable of free movement toward and from said bed.

779,806. PNEUMATICALLY-ACTUATED CLUTCH-OPERATING DEVICE. Alfred P. Schmucker, Franklin, Pa., assignor of one-third to John Player, River Forest, Ill. Filed Dec. 2, 1903. Serial No. 183,527.

A pneumatically-actuated clutch-operating device, consisting of a cylinder having two pistons of different areas, operably seated therein, a piston-rod rigidly connecting said piston, one end of said rod being extended through the head of the larger cylinder, and adapted to be attached to a clutch-lever, a pipe communication entering the chamber of the larger cylinder between the piston and the head thereof, a pipe entering the head of the smaller cylinder and establishing communication between the same and an air-receiver, means of opening communication between said pipes and between said first-mentioned pipe and the atmosphere, in combination with the lever of a clutch.

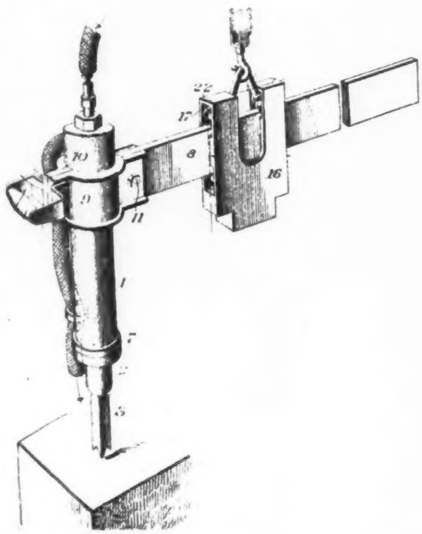
779,907. MOTOR AIR-PUMP. Edward Cheshire, Milwaukee, Wis. Filed Feb. 13, 1904. Serial No. 193,360.



The combination of a frame member, containing a pump-cylinder and a motor-housing, both of which are open at both ends, and two caps removably secured to the ends of said frame member thereby closing the cylinder at one end and inclosing a chamber at the other end of the housing with which said cylinder and motor-housing communicate, with a pump-piston in the cylinder, an electric motor in the motor-housing, and power-transmission mechanism connecting said motor and pump-piston, a portion of which mechanism lies within said chamber and a portion of which passes through the opening which connects said chamber with the motor-housing, substantially as specified.

780,140. AIR-TUBE FOR PNEUMATIC TIRES. John R. Taylor, Wandsworth Common, England. Filed Apr. 16, 1904. Serial No. 203,481.

779,943. PNEUMATIC TOOL. Herman G. Kotten, New York, N. Y. Filed Mar. 25, 1904. Serial No. 200,062.



The combination of a pneumatic tool, a head having rollers therein, a bar supported upon said rollers, means for securing said pneumatic tool to said bar, a bracket secured to said head and a chain hoist adapted to coact with said bracket, the latter being suspended from said chain hoist and adapted to freely swing therefrom.

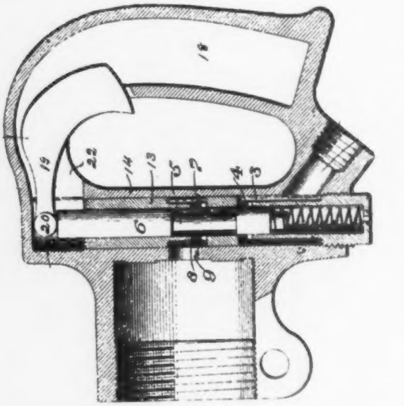
780,452. PNEUMATIC TIRE. Wilhelm Struck, Friedenau, near Berlin, Germany, assignor to B. Polack, Waltershausen, Thuringen, Germany. Filed Apr. 8, 1904. Serial No. 202,225.

780,462. PNEUMATIC TIRE. William W. Walter, Aurora, Ill., assignor of one-half to Jay D. Miller, Geneva, Ill. Filed Aug. 17, 1904. Serial No. 220,994.

780,517. PNEUMATIC MACHINE FOR CLEANING FABRICS. Zelma B. Mead and Seymour G. Mead, Cincinnati, Ohio, assignors to The American Pneumatic Carpet Cleaning Company, Cincinnati, Ohio, a Corporation of Ohio. Filed July 29, 1901. Serial No. 70,073.

780,550. ELECTROPNEUMATIC CONTROL SYSTEM. Eugene R. Carichoff, East Orange, N. J., assignor to General Electric Company, a Corporation of New York. Filed June 30, 1904. Serial No. 214,695.

780,354. PNEUMATIC TOOL. William H. Keller, Philadelphia, Pa. Filed Oct. 15, 1904. Serial No. 228,628.



A device of the character named, a grasping-handle, a head-block to which said handle is secured, a chamber in one end of said head-block, a throttle-valve located in said head-block and extending transversely thereof and a manually-operated lever having one portion extending outside of said handle and the other end extending into said head-block chamber and in sliding contact with said throttle-valve for actuating the same.

780,595. CARRIER FOR PNEUMATIC DESPATCH-TUBE-SYSTEMS. Charles H. Burton, Boston, Mass., assignor to American Pneumatic Service Company, Dover, Del., a Corporation of Delaware. Filed Mar. 28, 1904. Serial No. 200,262.

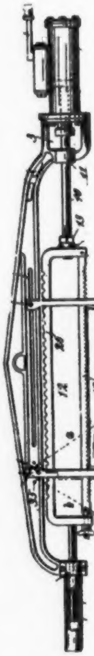
780,813. AIR-BRAKE MECHANISM. Henry N. Ransom, Cleveland, Ohio. Filed May 19, 1904. Serial No. 208,642.

781,029. FLUID-PRESSURE BRAKE SYSTEM. George M. Spencer and Christopher J. Grellner, St. Louis, Mo. Filed June 25, 1903. Serial No. 162,997.

781,087. AUTOMATIC VACUUM CAN-SEALING MACHINE. Edwin Norton and John G. Hodgson, Maywood, Ill., assignors to The Automatic Vacuum Canning Company, Chicago, Ill., a Corporation of Illinois. Filed Nov. 9, 1900. Serial No. 35,904.

781,112. PNEUMATIC TOOL. John F. Tippett, Kansas City, Mo., and James D. Parker, Kansas City, Kans. Filed Apr. 8, 1904. Serial No. 202,267.

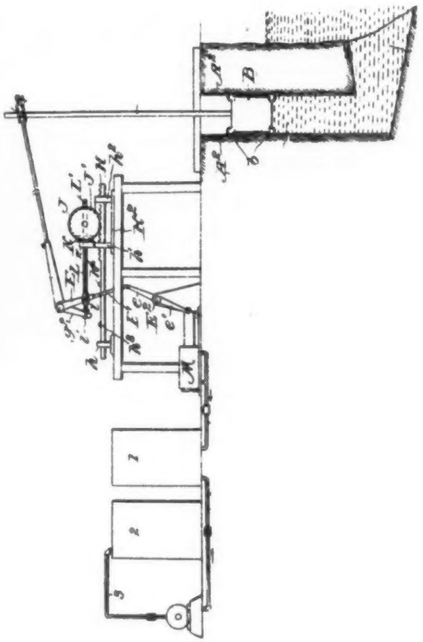
A tool of the character described, consisting in a main frame, a cylinder secured to one end thereof, a piston reciprocably arranged therein, a piston-rod secured to the piston and extending through one end of the cylinder, a reciprocating frame attached at one end to the outer end of the piston-stem, and a stem on the opposite end of the reciprocating frame slidingly arranged in the adjacent end of the main frame.



A tool of the character described, consisting in a bow-shaped main frame provided at its depending ends with horizontally-alined bearings, and a forwardly-extending sleeve formed integral with the front portion of frame in horizontal alinement with the bearings, in combination with a cylinder secured to the rear end of the main frame, a piston reciprocably arranged therein, a piston-rod secured to the piston and extending through one end of the cylinder and the adjacent bearing in the main frame, a tool carrying reciprocating frame attached at one end to the

outer end of the piston stem, and a stem on the opposite end of the reciprocating frame slidingly arranged in the adjacent bearing of the main frame and the sleeve.

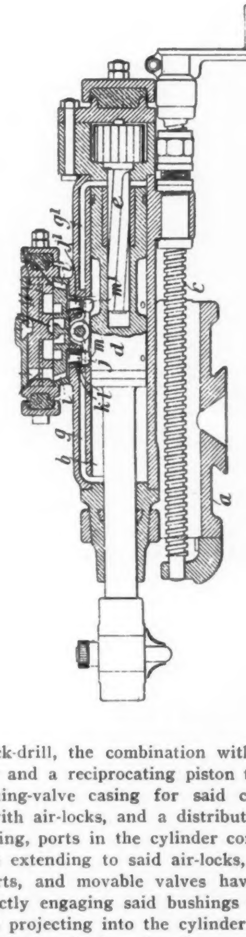
781,113. WAVE-MOTOR. David G. Weems, Bonanza, Colo. Filed May 5, 1904. Serial No. 206,445.



A wave-motor the combination with a float-actuated lever, having an automatically-adjusted transmitting-arm, of a rock-shaft actuated from said arm and provided with a plurality of pump-operating arms, low and high pressure pumps connected to said arms, low-pressure tanks connected with the low-pressure pumps, high-pressure tanks supplied by the high-pressure pumps from the low-pressure tanks; and an offtake from the high-pressure tanks to supply a suitable motor.

781,361. PNEUMATIC DOOR CHECK AND CLOSER. Oliver Rice, Oakland, Cal., assignor to Ideal Door Check Spring Company, San Francisco, Cal., a Corporation of California. Filed Apr. 5, 1904. Serial No. 201,669.

781,241. ROCK-DRILL. William C. Stephens, Camborne, England. Filed Oct. 12, 1903. Serial No. 176,686.



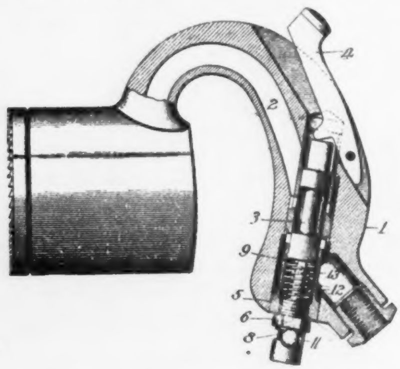
A rock-drill, the combination with a working cylinder and a reciprocating piston therein, of a distributing-valve casing for said cylinder provided with air-locks, and a distributing valve in said casing, ports in the cylinder connected with passages extending to said air-locks, bushings in said ports, and movable valves having portions for directly engaging said bushings and wearing portions projecting into the cylinder in the path of the piston and adapted to be operated thereby, substantially as described.

781,330. AIR-PRESSURE REGULATOR. Joseph H. Chase, Buffalo, N. Y. Filed July 1, 1903. Serial No. 163,965.

An air-pressure regulator comprising a collapsible casing having an elongated air-opening therein, a spring-valve secured with one end in

the chamber at one end of the said opening, a stop secured to a movable portion of the casing, a slot formed in said movable portion in line with the spring-valve, a bolt passing through said stop and said slot and means for holding said stop in any position within the length of said slot, said stop contacting with said valve and causing the same to close when the chamber is collapsed.

781,276. PNEUMATIC HAMMER. William O. Duntley, Chicago, Ill., assignor to Chicago Pneumatic Tool Company, Chicago, Ill., a Corporation of New Jersey. Filed Feb. 21, 1903. Serial No. 144,449.



A pneumatic hammer having a throttle-valve, means arranged in axial alinement with the valve for normally locking the same in its normally closed position.

A pneumatic hammer having a grasping-handle and a reciprocating throttle-valve therein, a plug 6 screwing into the handle adjacent the valve and having a central bore and also the communicating slots 7 and 8, a pin or bolt 9 arranged to slide in said bore and having a bent or angled portion 10 normally positioned in the slot 8, whereby the pin is locked in inward position, and a coiled spring 12 surrounding the pin and secured at one end to the pin and at its other end to the plug whereby such spring exerts a torsional stress to throw the bent end of the pin into slot 8 and also exerts an expanding stress to normally project the pin inwardly toward the valve to prevent its opening movement.

According to the announcement already made, first choice in the advertising competition, conducted by "COMPRESSED AIR" at the request of the Ingersoll-Sergeant Drill Company, appears this month on page 1 as the regular advertisement of the Ingersoll-Sergeant Drill Company.

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